



1 / 50

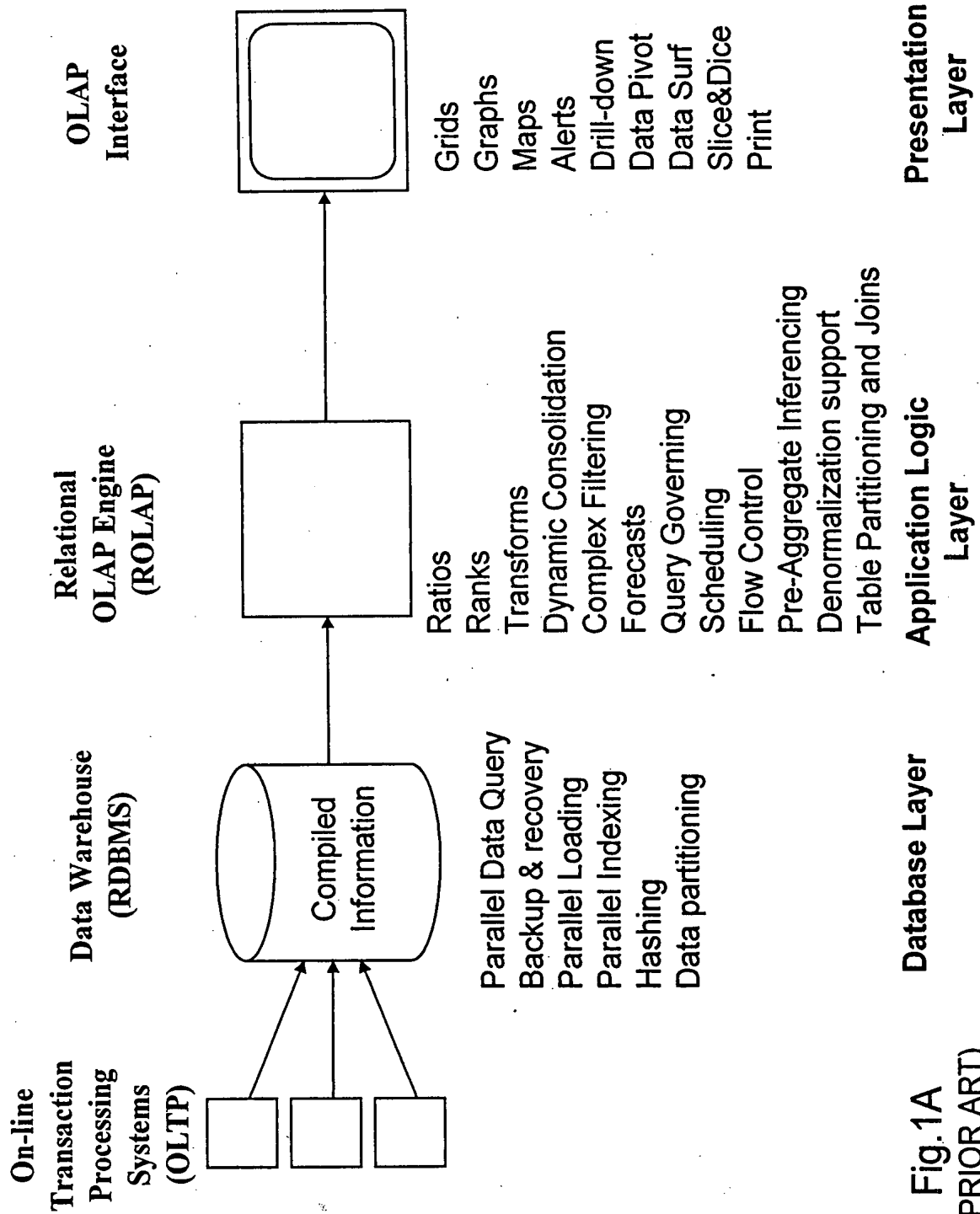


Fig.1A
(PRIOR ART)

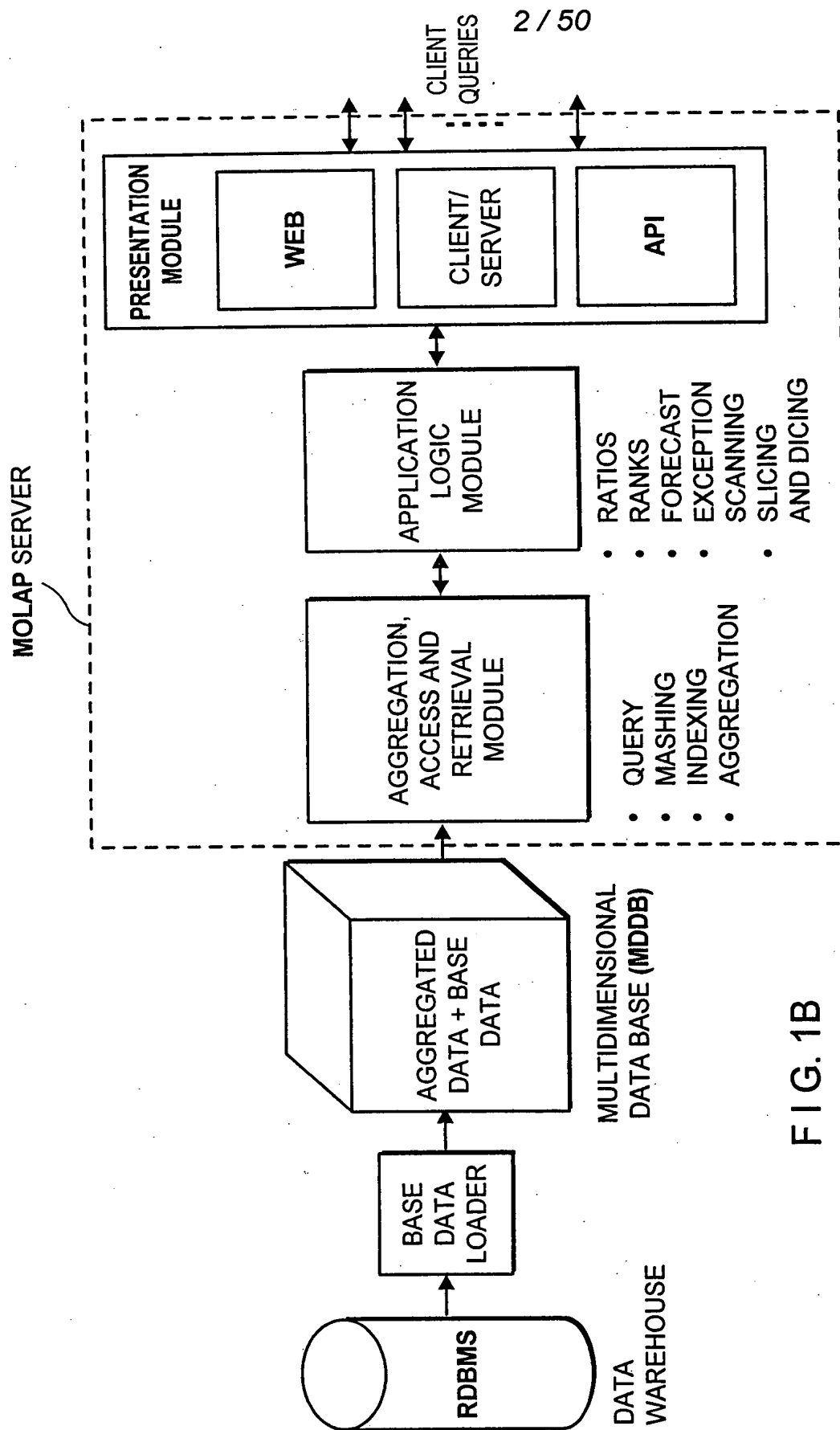


FIG. 1B

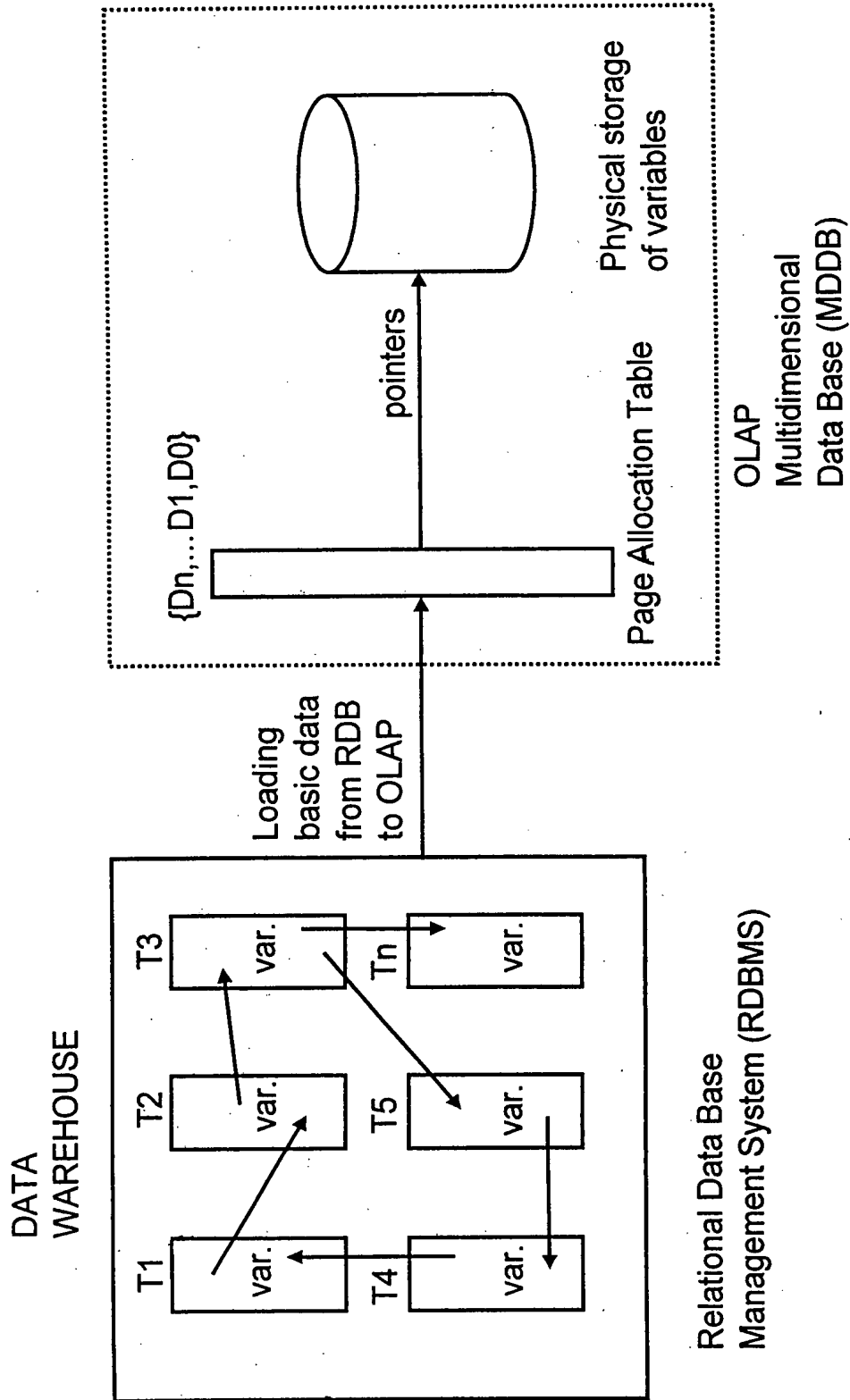
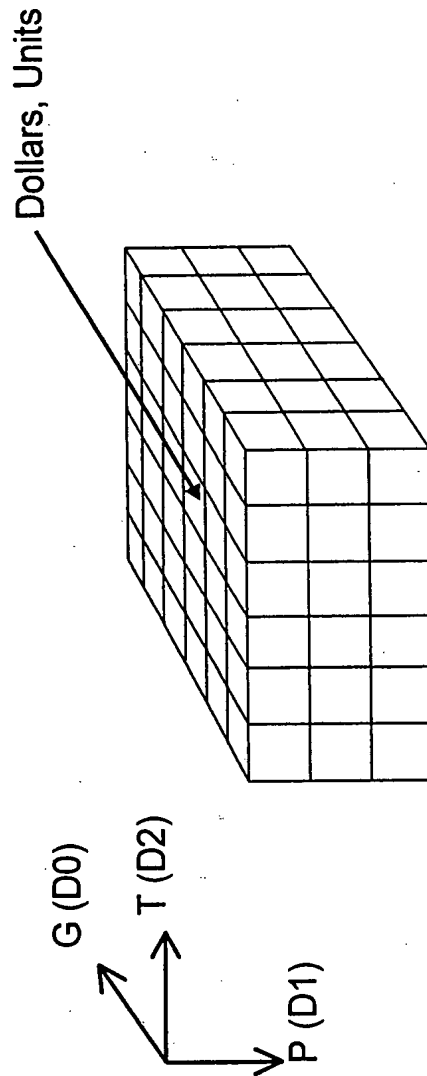


Fig. 2A
(PRIOR ART)



G geography (e.g. cities, states, countries, continents)
 T time (e.g., days, weeks, months, years)
 P products (e.g. all products, by manufacturer)

Fig. 2B
 (PRIOR ART)

**Array structure of a
multidimensional variable**

| | | D0 | | | | | |
|------|-------|----|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| D2=0 | D1= 0 | | | | | | |
| | D1= 1 | | | | | | |
| | D1= 2 | | | | | | |
| D2=1 | D1= 0 | | | | | | |
| | D1= 1 | | | | | | |
| | D1= 2 | | | | | | |
| D2=2 | D1= 0 | | | | | | |
| | D1= 1 | | | | | | |
| | D1= 2 | | | | | | |
| D2=3 | D1= 0 | | | | | | |
| | D1= 1 | | | | | | |
| | D1= 2 | | | | | | |
| D2=3 | D1= 0 | | | | | | |
| | D1= 1 | | | | | | |
| | D1= 2 | | | | | | |

Fig. 2C
(PRIOR ART)

Page Allocation Table pointing on physical records of a multidimensional variable (e.g. the two first rows of a variable of FIG. 2B reside in page # 0)

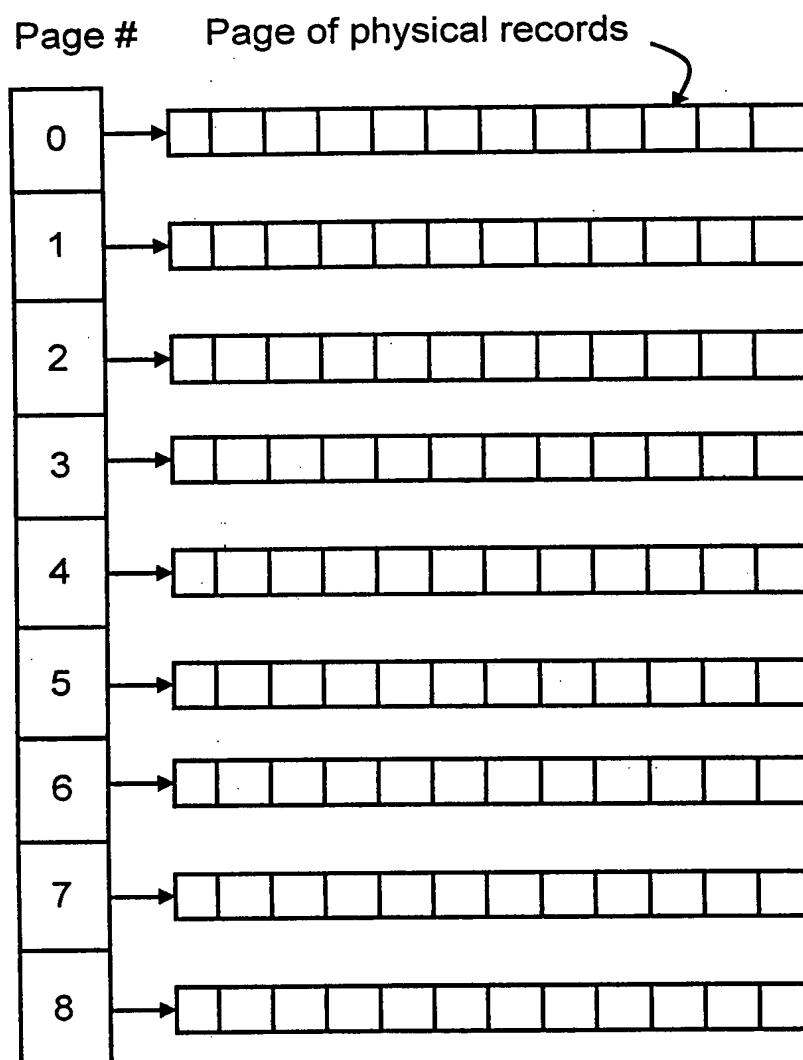


Fig. 2D
(PRIOR ART)

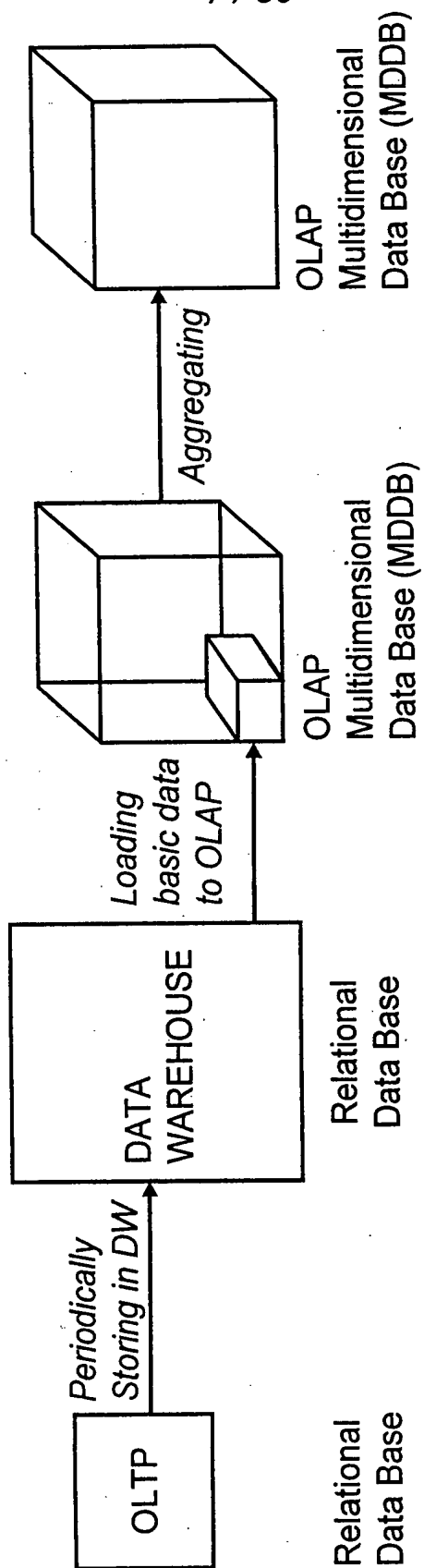


Fig. 3A
(PRIOR ART)

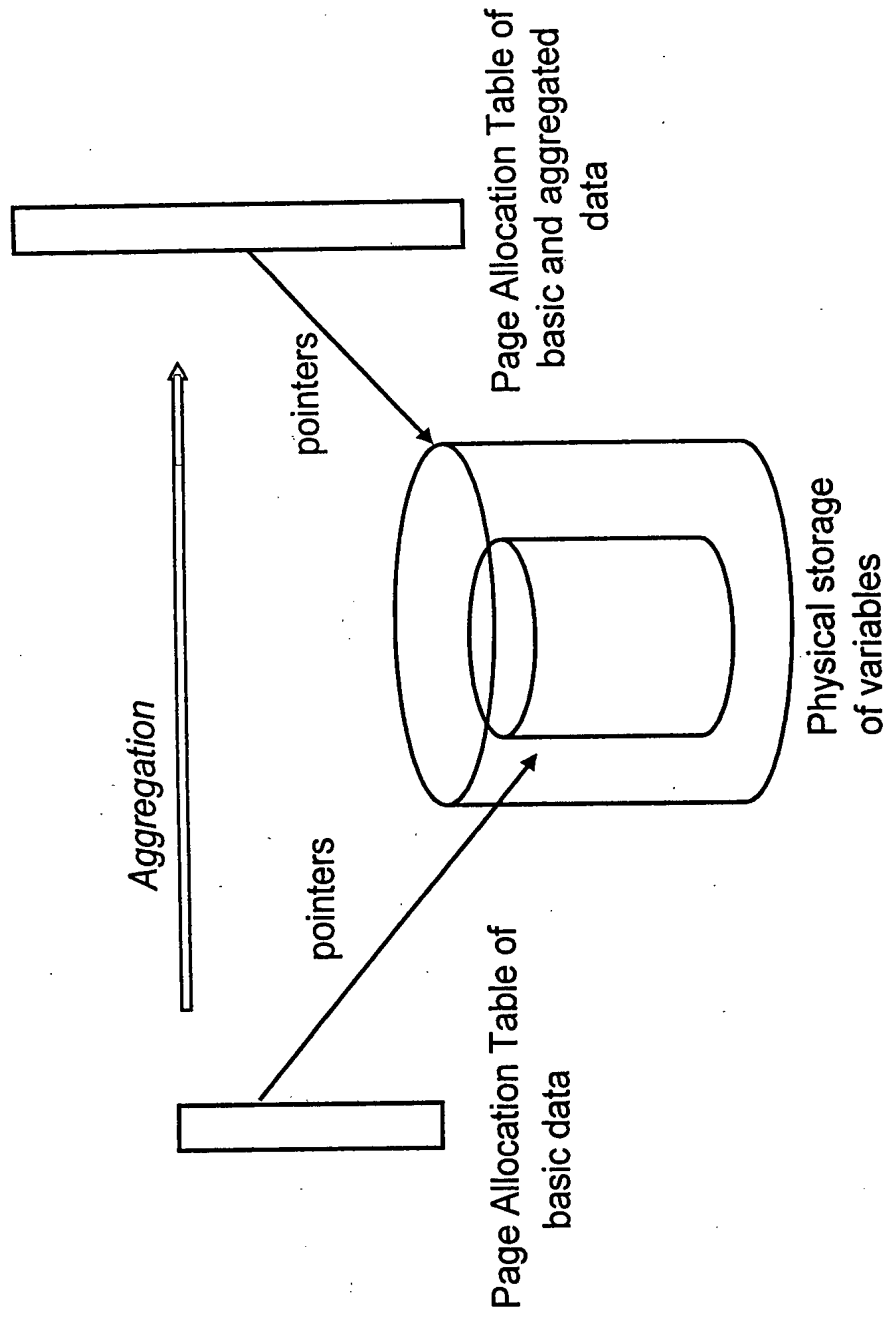


Fig. 3B
(PRIOR ART)

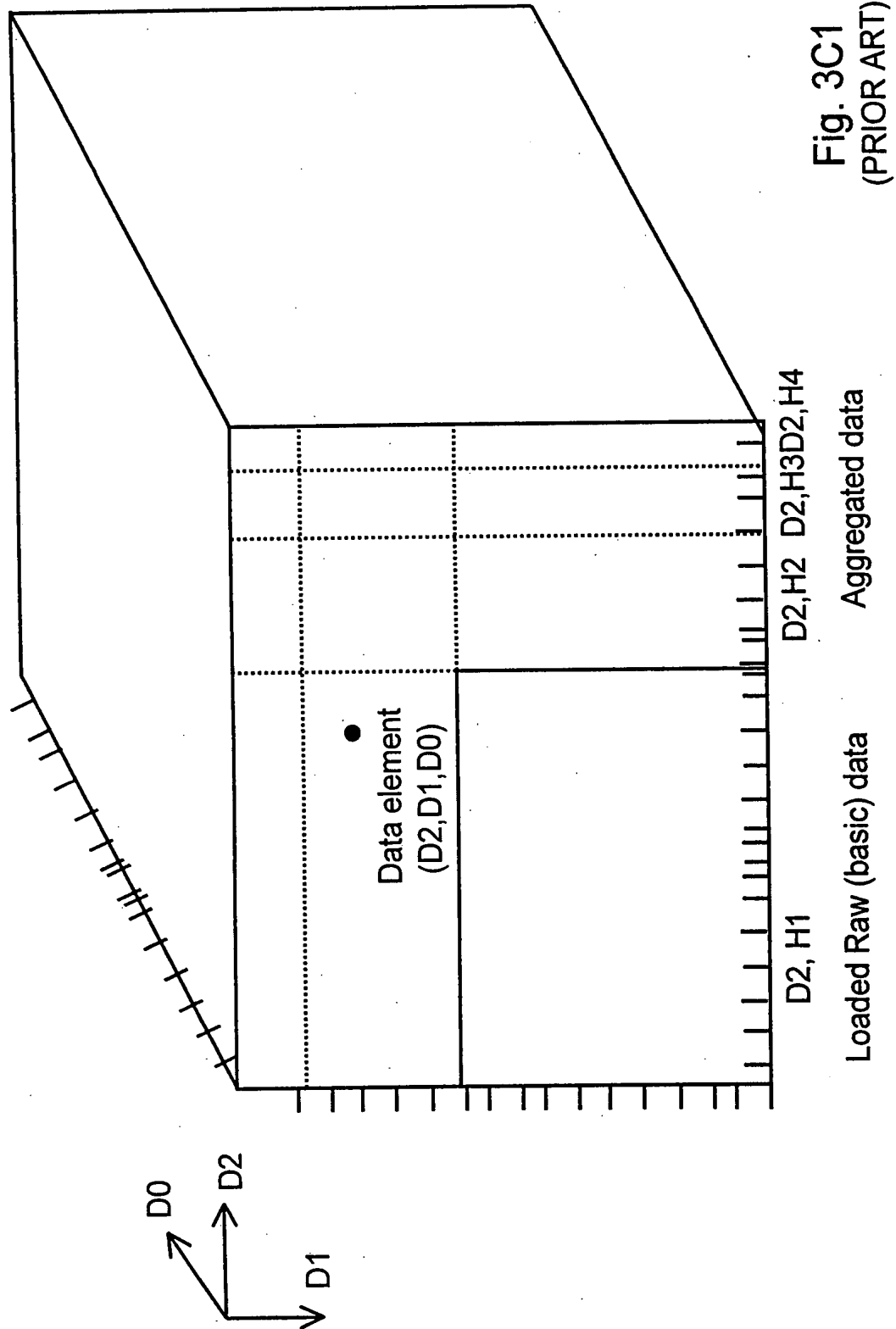


Fig. 3C1
(PRIOR ART)

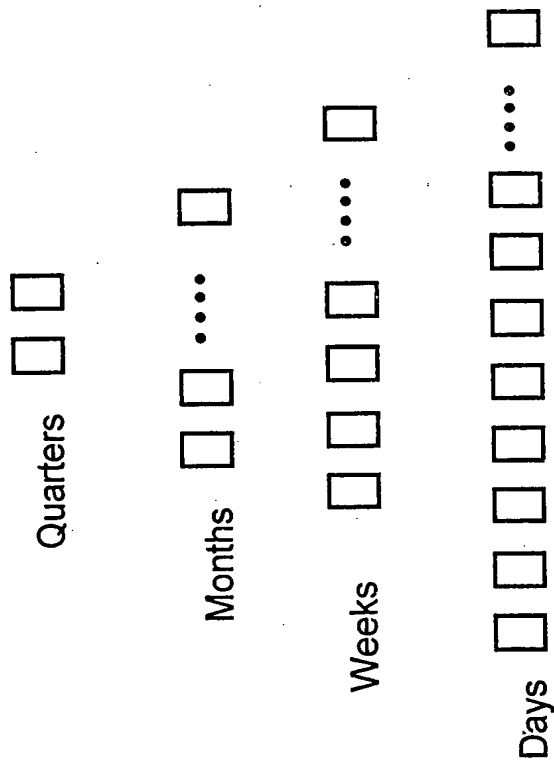


Fig. 3C2
(PRIOR ART)

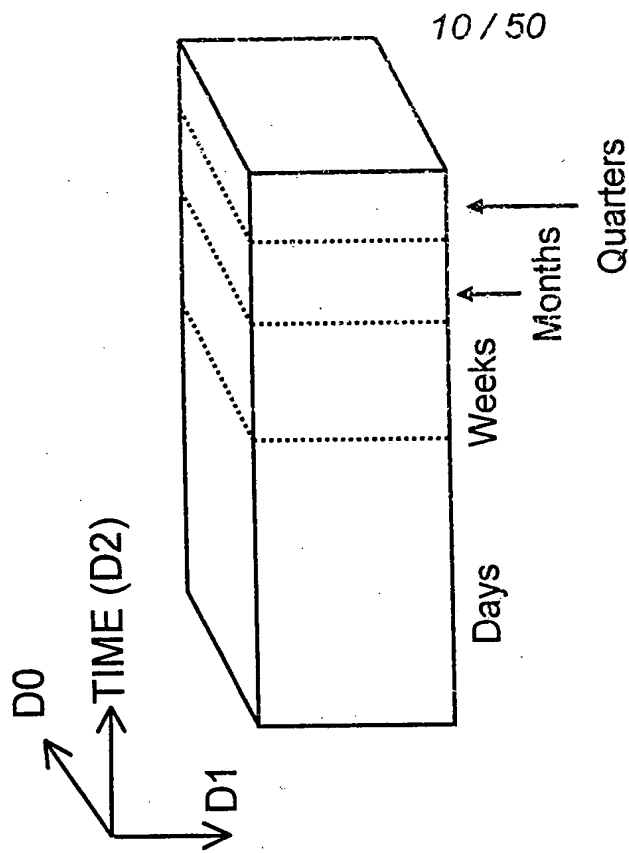


Fig. 3C3
(PRIOR ART)

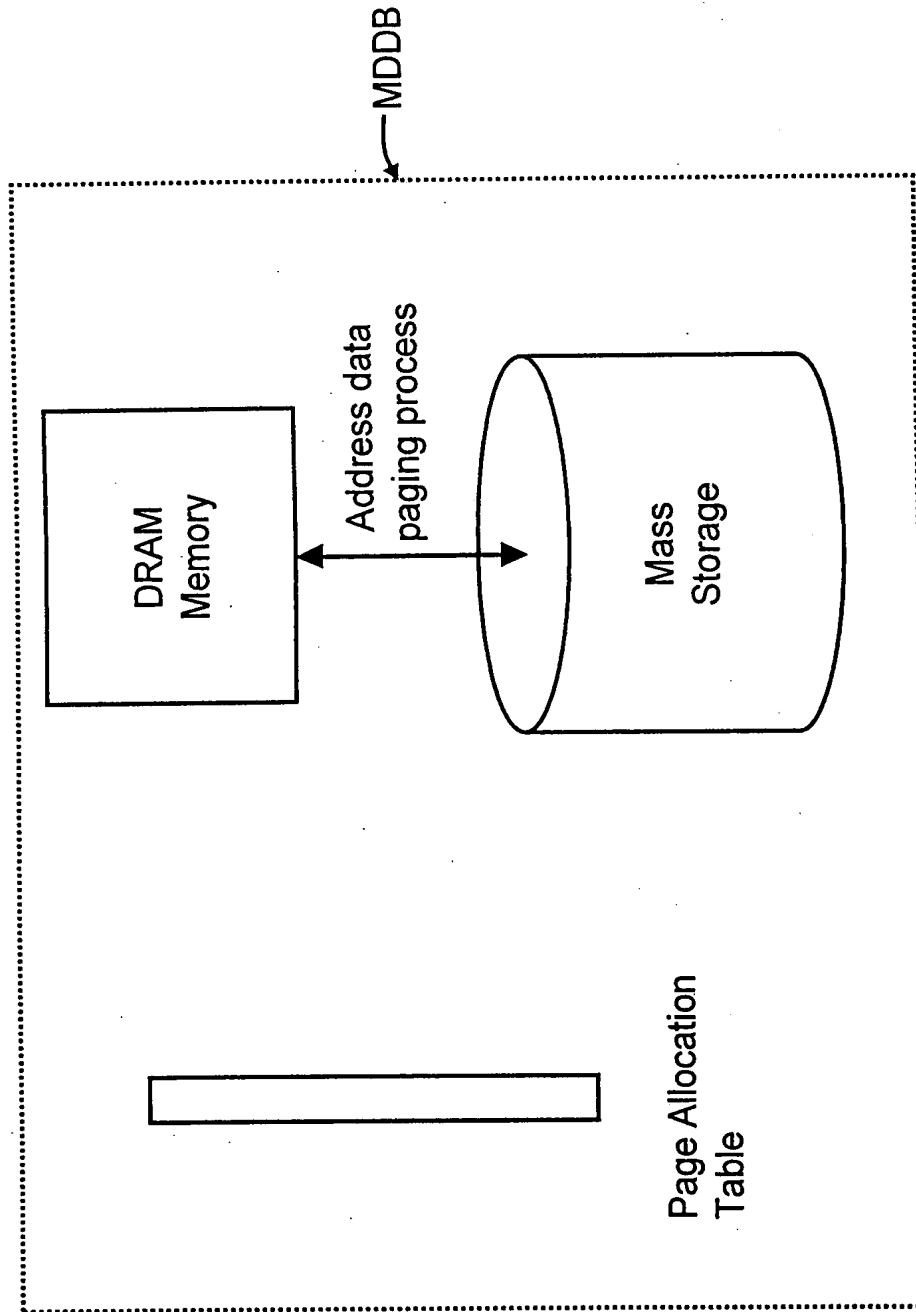


Fig. 4
(PRIOR ART)

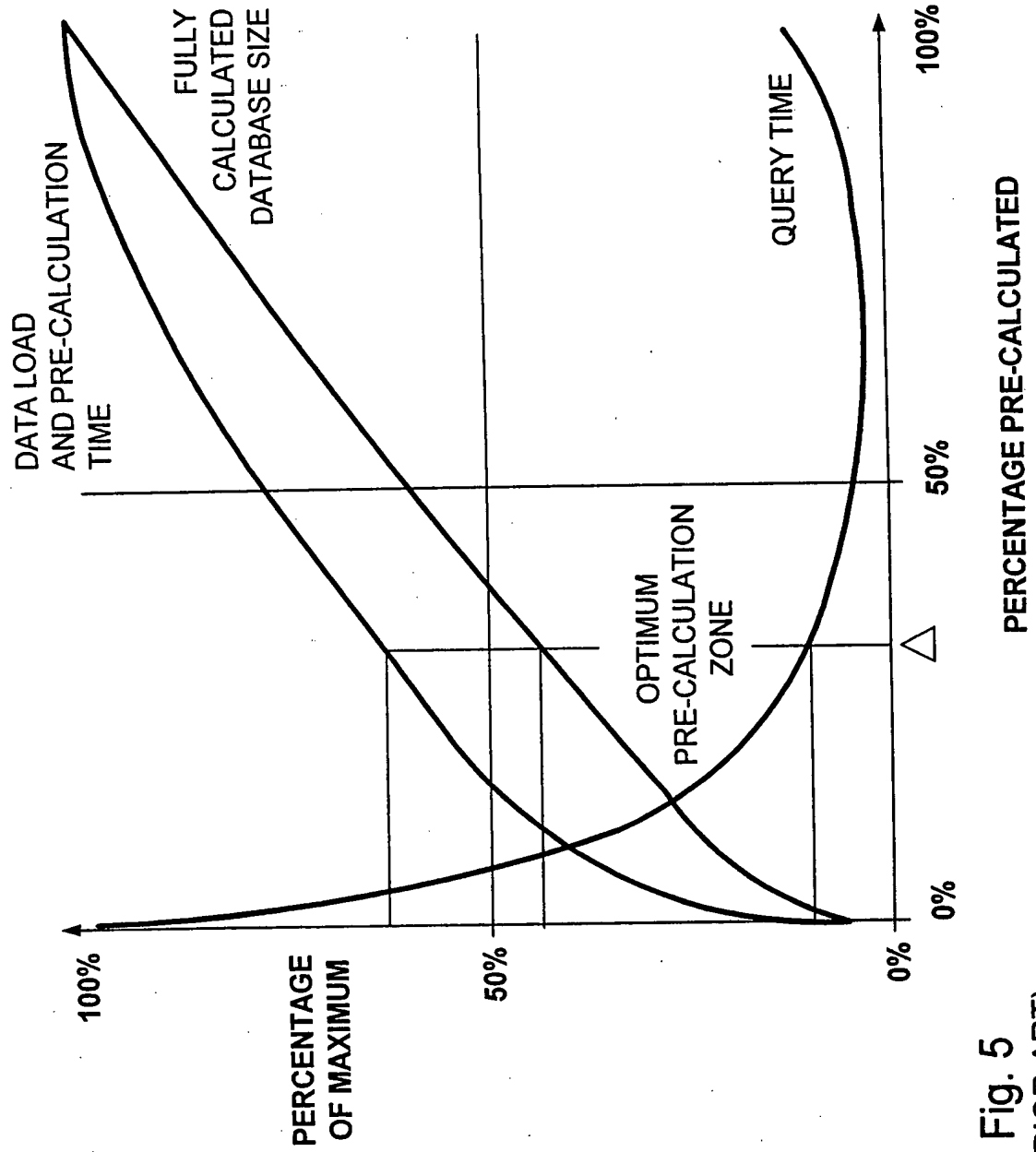


Fig. 5
(PRIOR ART)

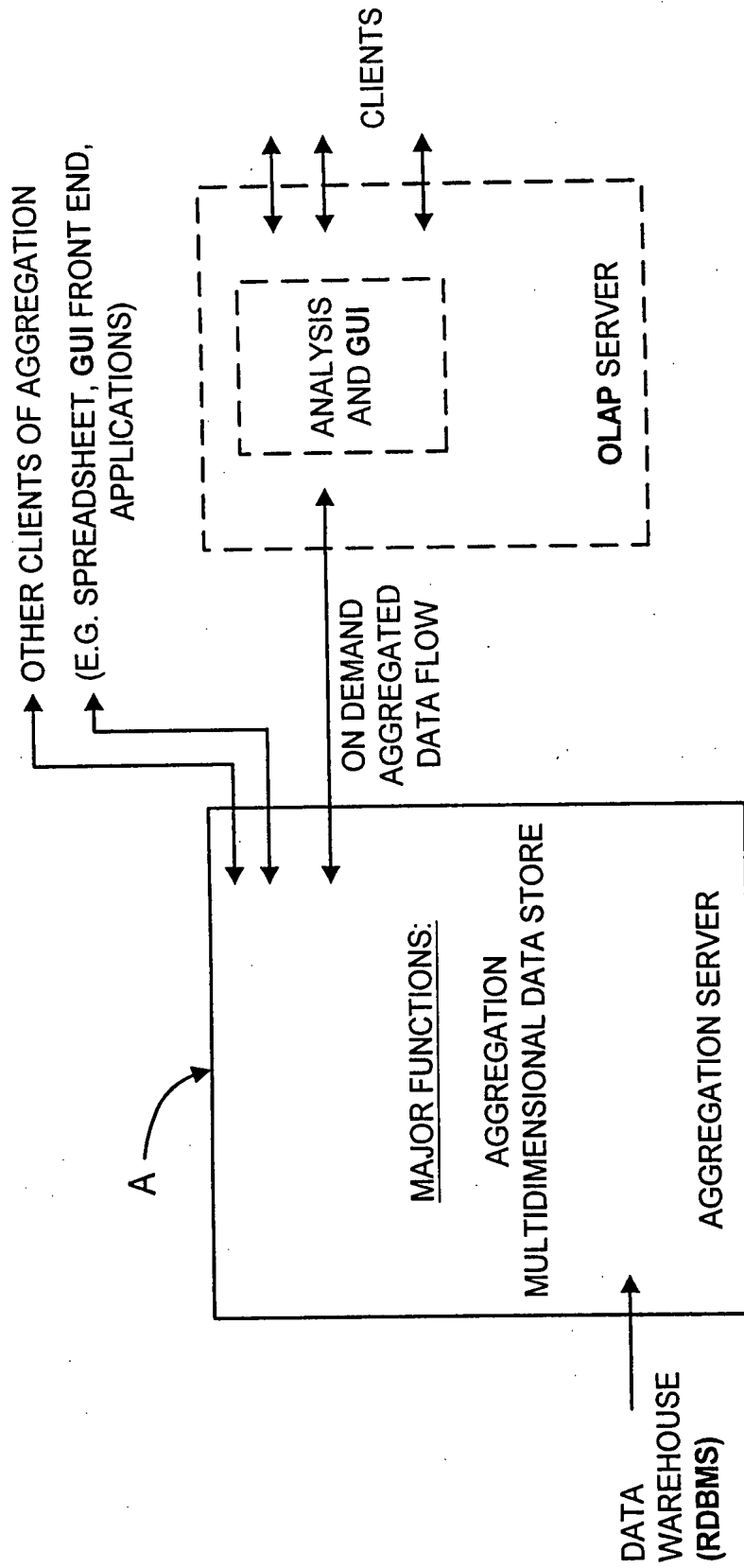


FIG. 6A

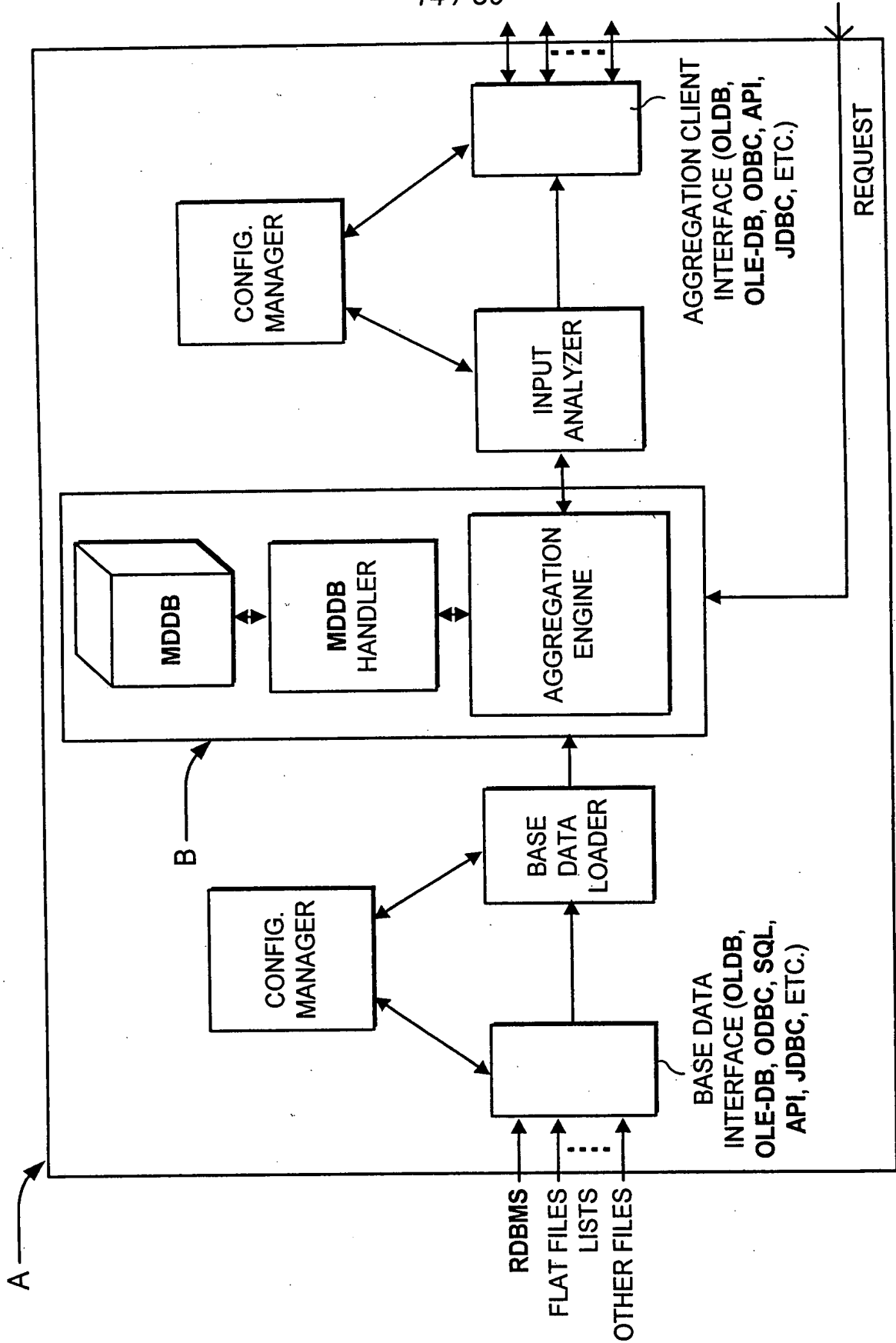


FIG. 6B

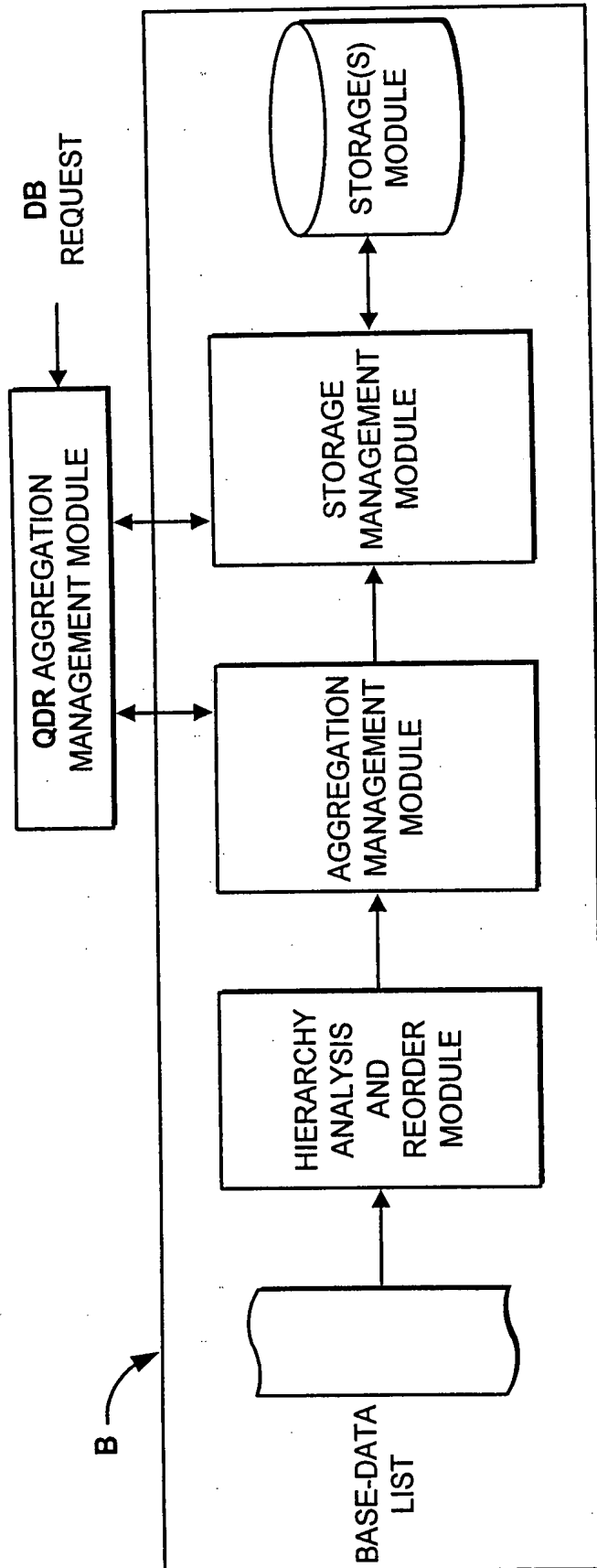


FIG. 6C

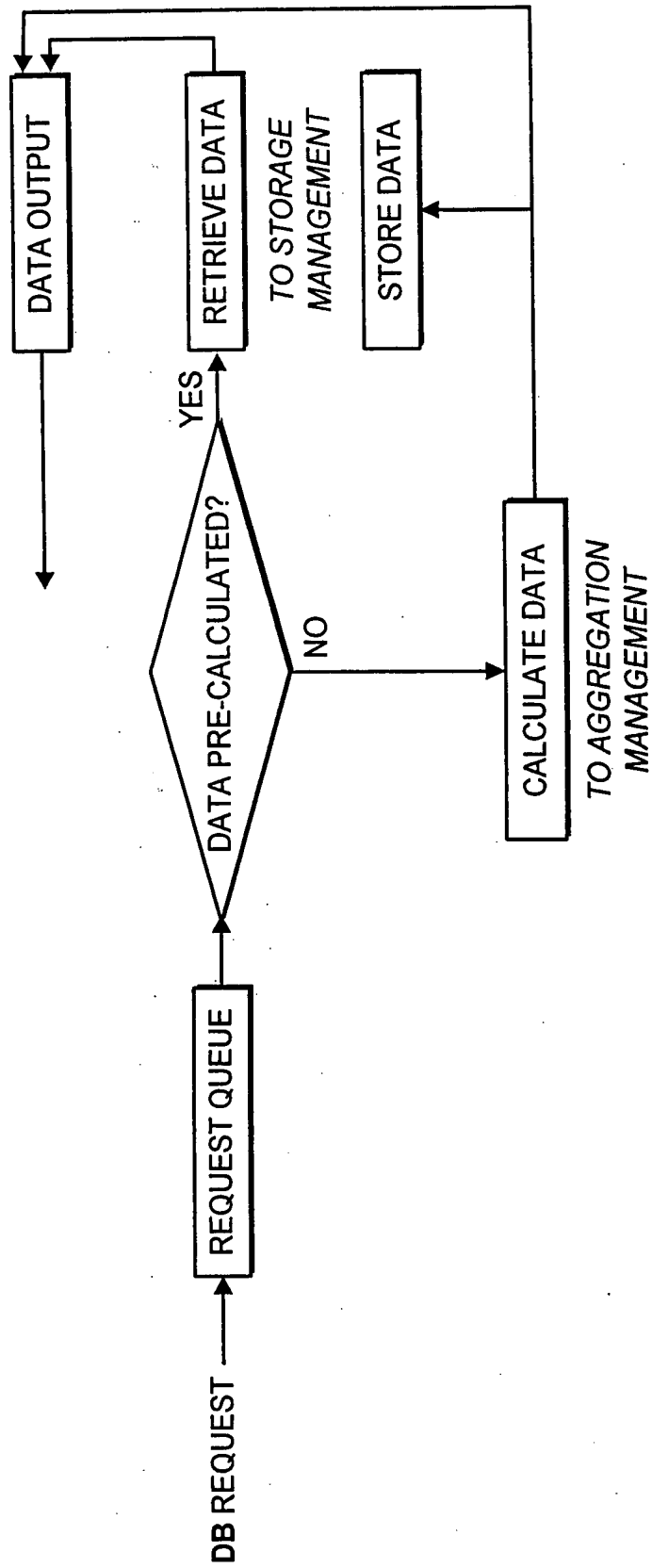


FIG. 6D

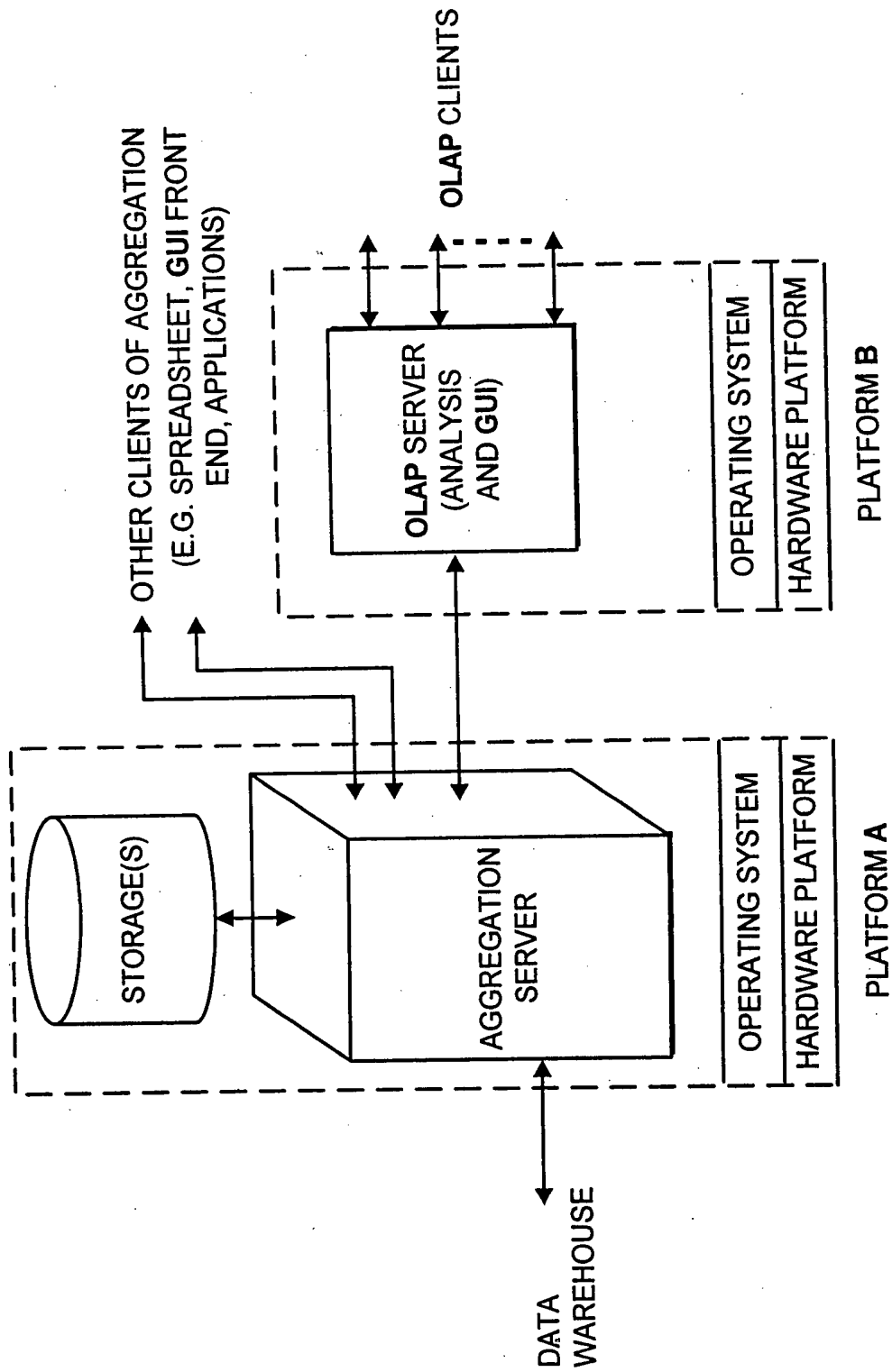


FIG. 7A

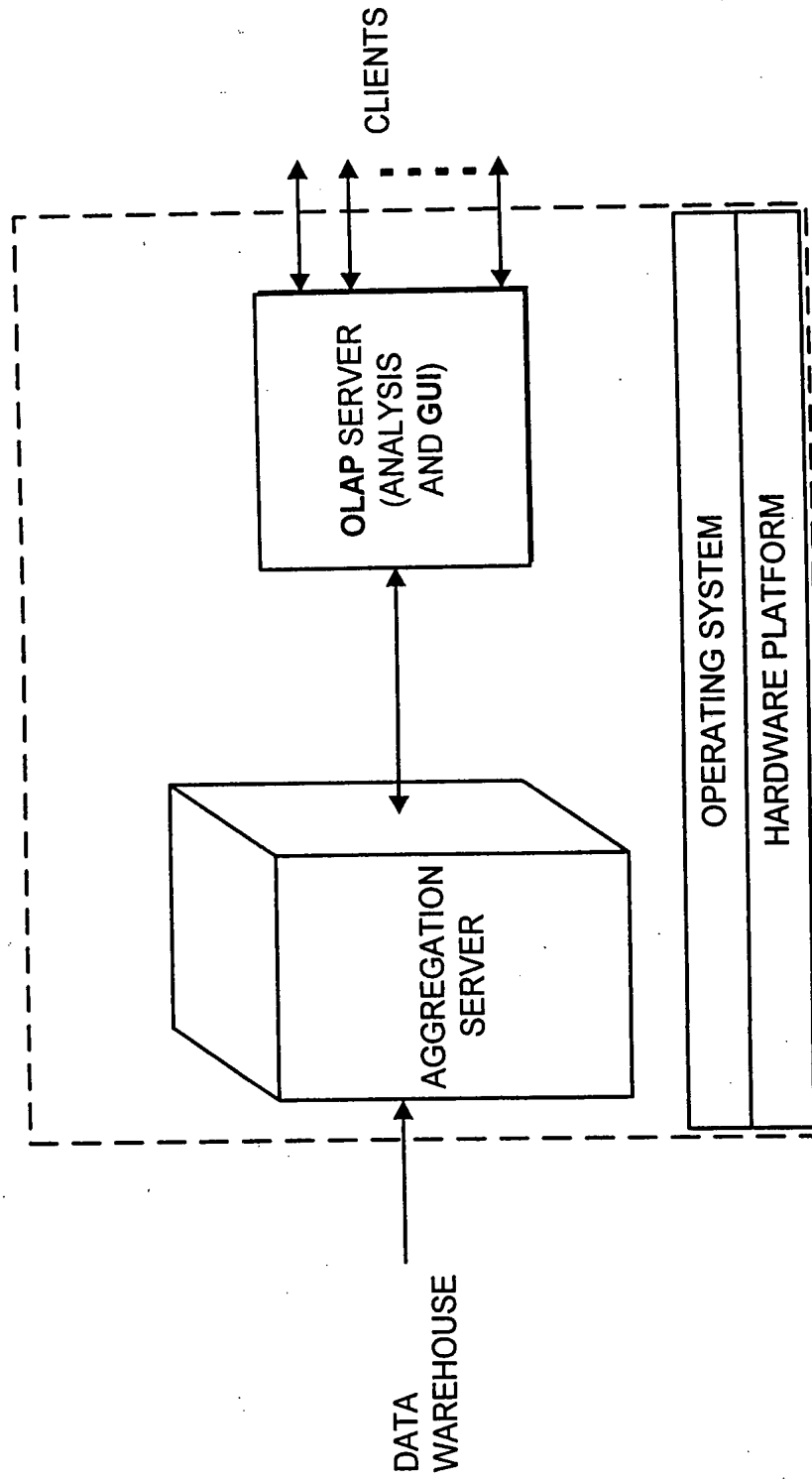


FIG. 7B

| | NBR. OF DIM. OF DIM. | NBR. OF ATOMIC DATA DATA VALUES | LEAF NODE DENSITY % | NUMBER OF VALUES IN CUBE AFTER ROLL-UP | ORACLE EXPRESS V.6.2 | IMPLEMENTATION OF CURRENT INVENTION |
|----|----------------------|---------------------------------|---------------------|--|----------------------|-------------------------------------|
| D1 | 6 | 302M | 9 | 427 M | 16 h | 15 m |
| D2 | 4 | 414M | 1.27 | 969 M | 50 m | 5 m |
| D3 | 5 | 14,499M | 0.03 | 63,954 M | 31 h | 1h 23 m |
| D4 | 6 | 623,494M | $8 * 10^{-4}$ | 7,930 G | EXCEEDS 48 h | 2 h 20 m |
| D5 | 6 | 243,000M | 10^{-8} | 1,160,000 G | 22 h | 4 m |
| D6 | 4 | 7M | DEFINED AS 100 | 19 M | 15 m | 1 m |

FIG. 8A

FIG. 9A

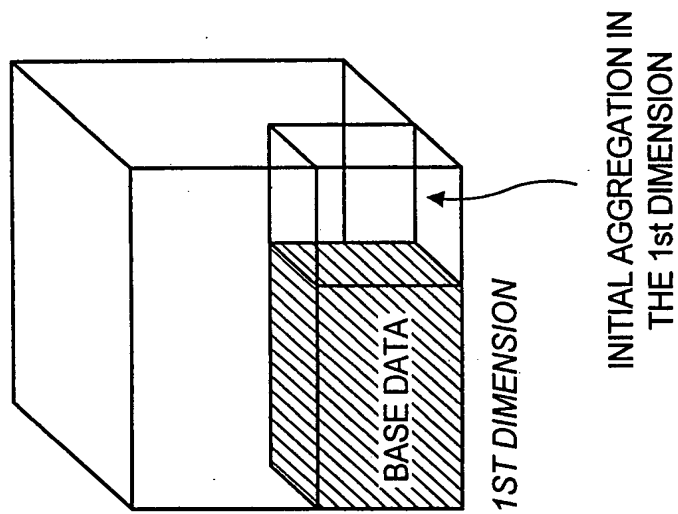
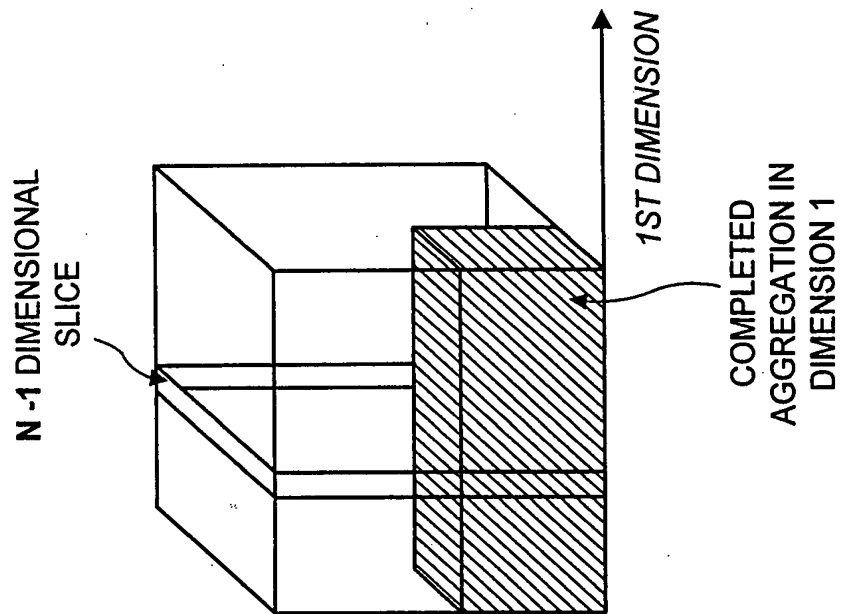
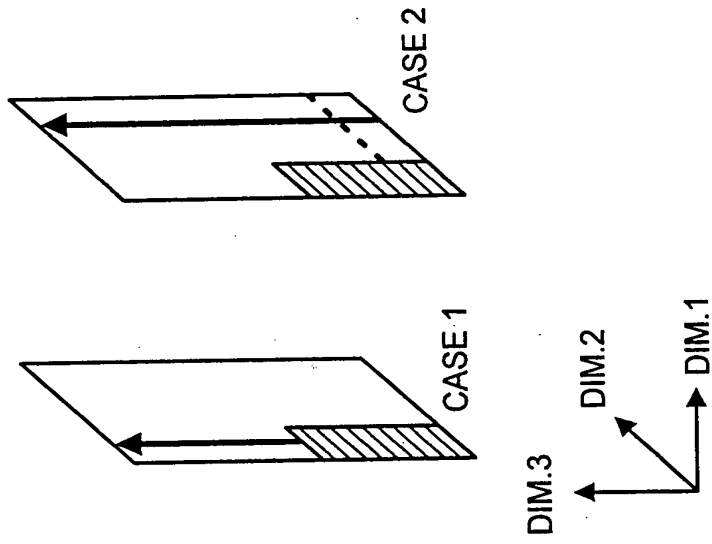


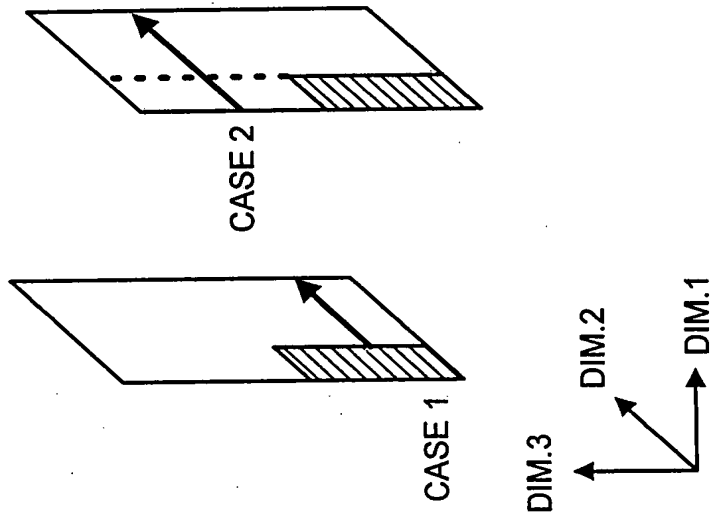
FIG. 9B





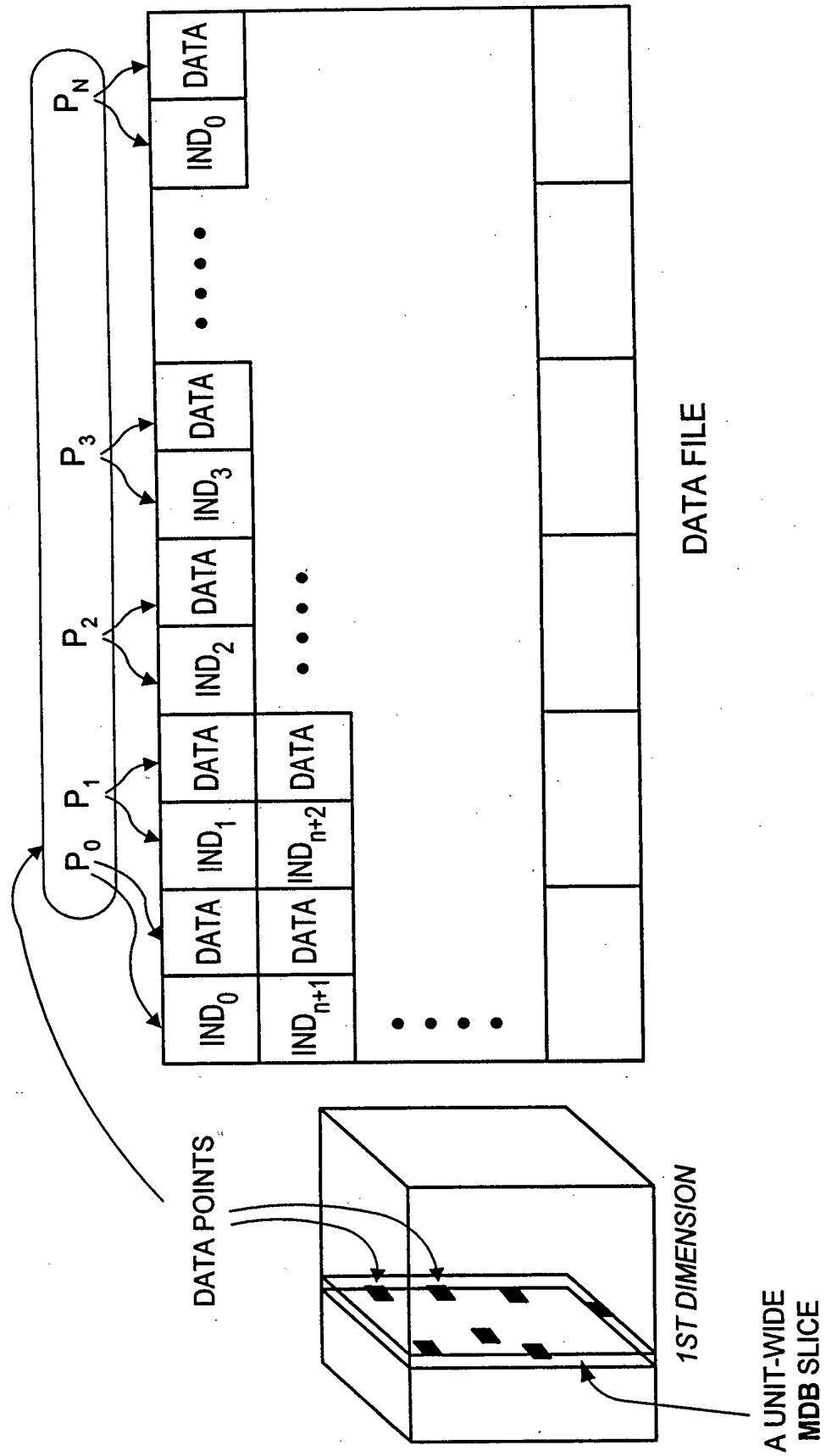
A. DIRECTED AGGREGATION IN
DIMENSION 3, CASES 1 AND 2

FIG. 9C2



A. DIRECTED AGGREGATION IN
DIMENSION 2, CASES 1 AND 2

FIG. 9C1



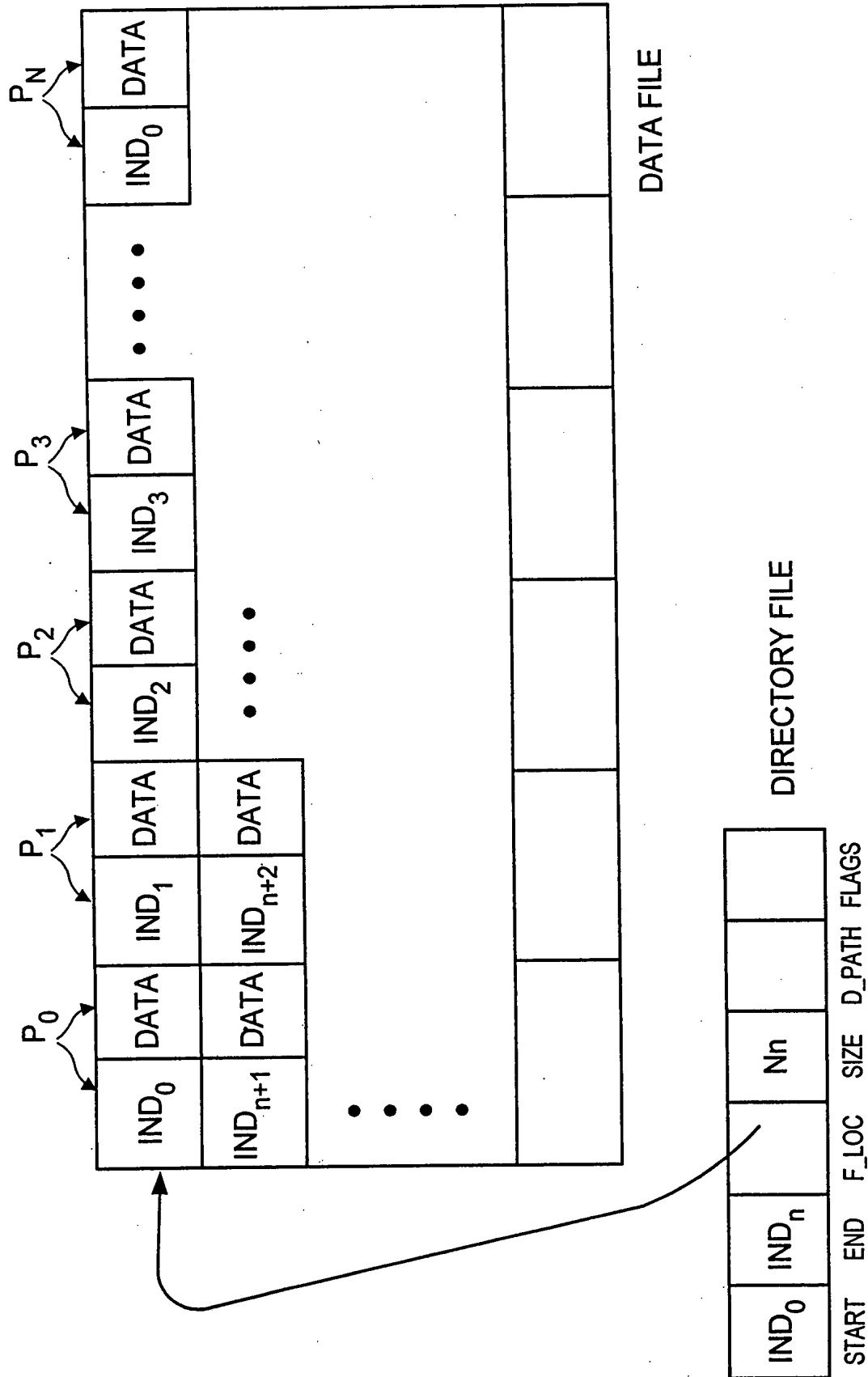
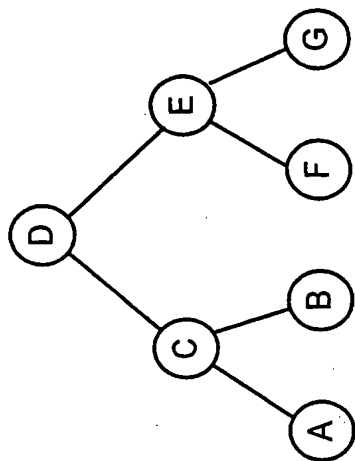
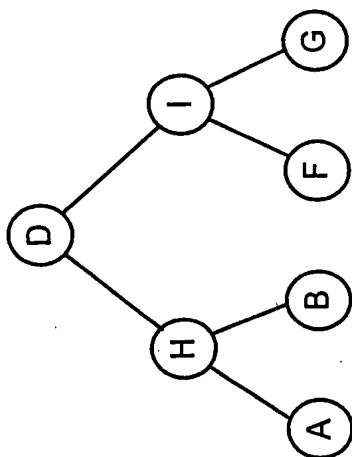
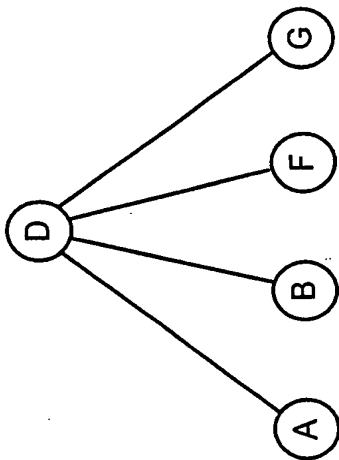


FIG. 10B

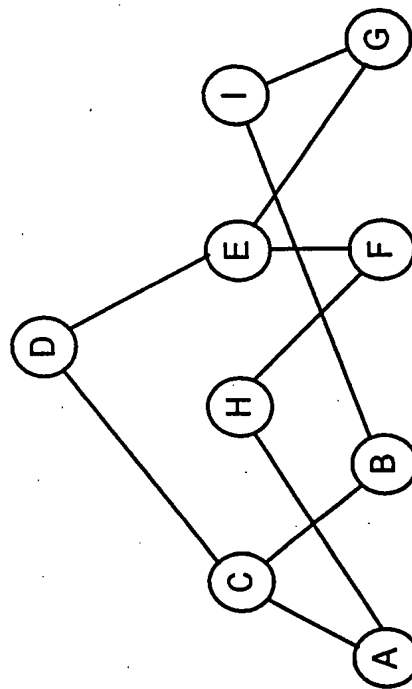


STRUCT. 3

STRUCT. 2

STRUCT. 1

FIG. 11A



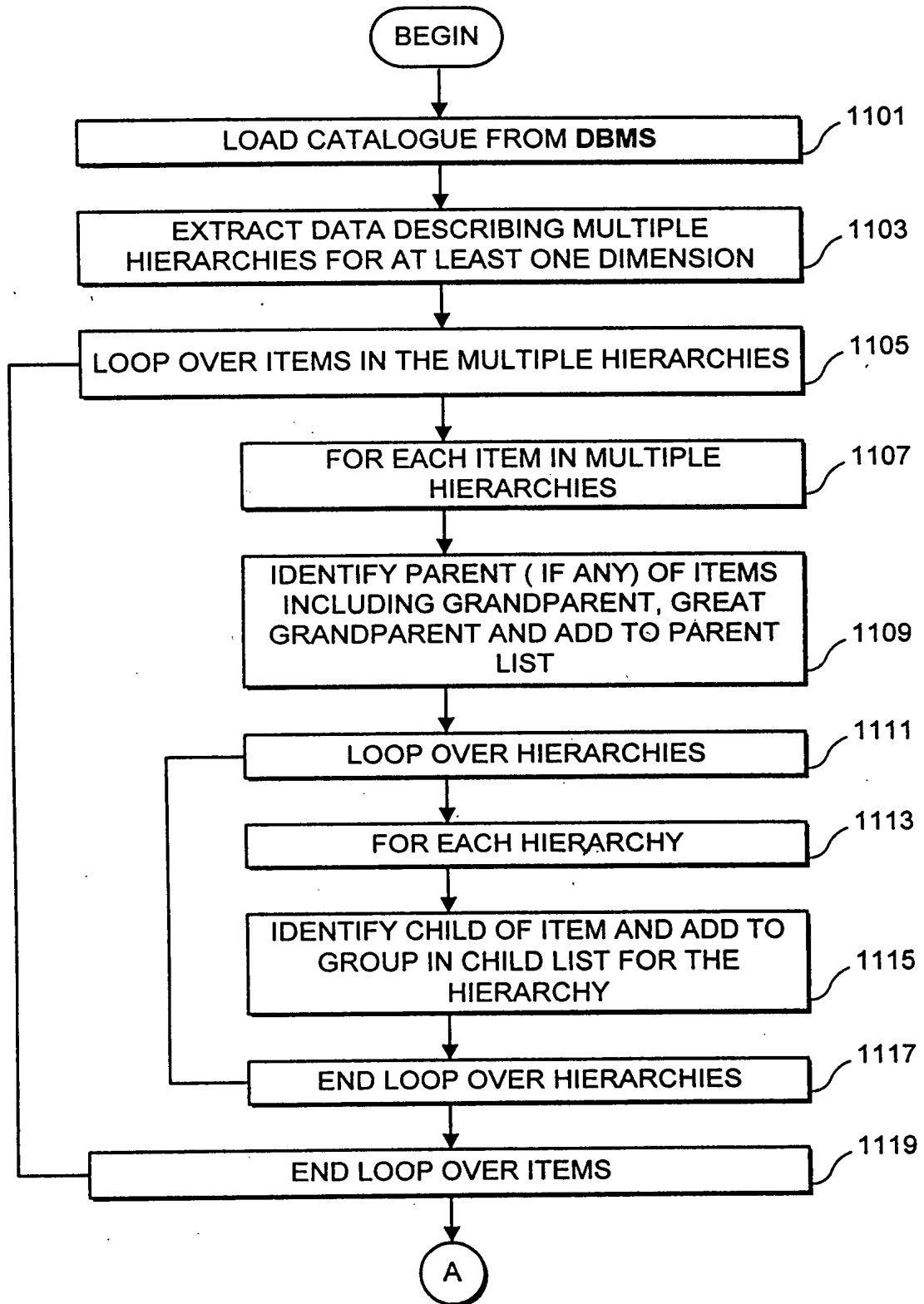


FIG. 11C(i)

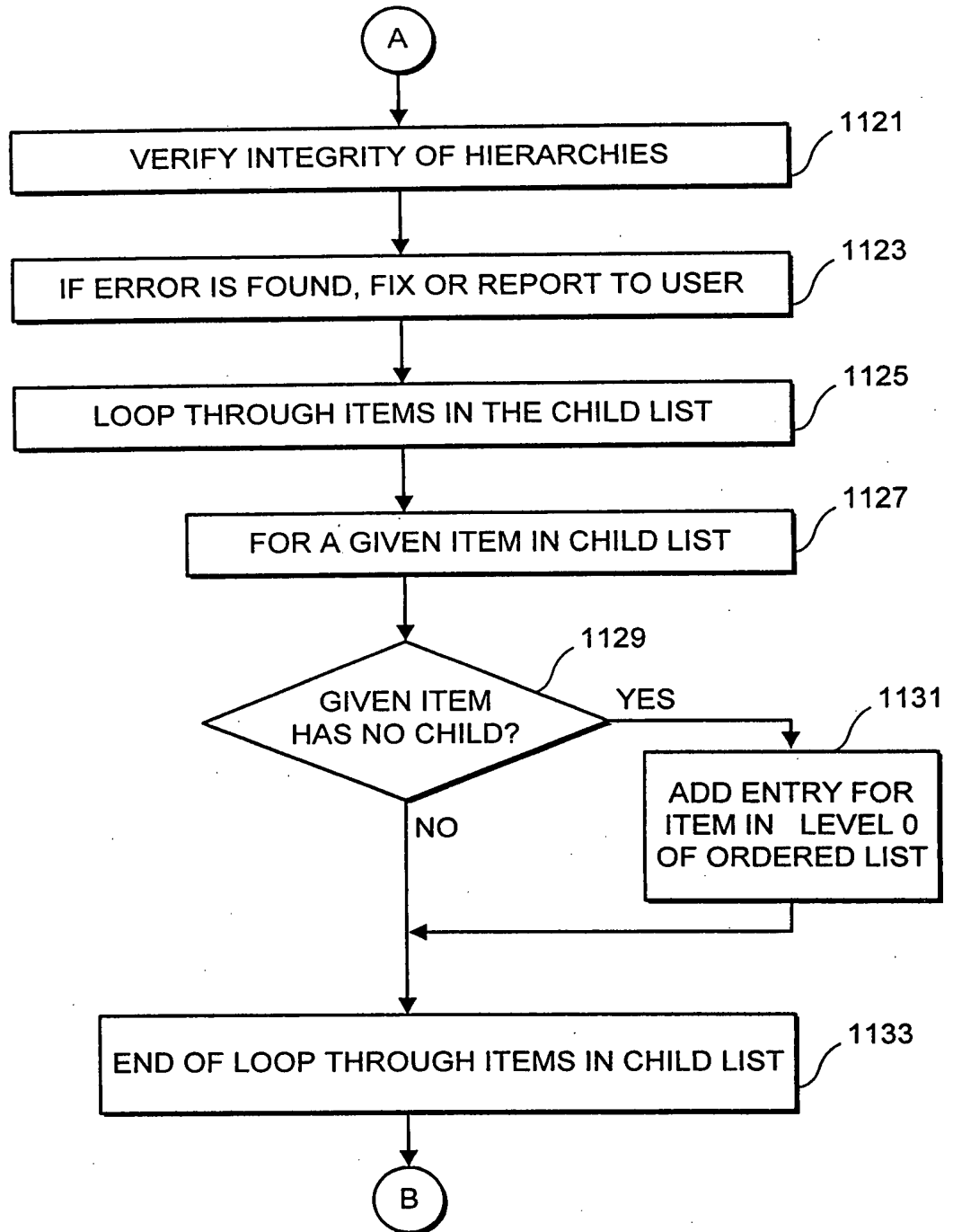


FIG. 11C(ii)

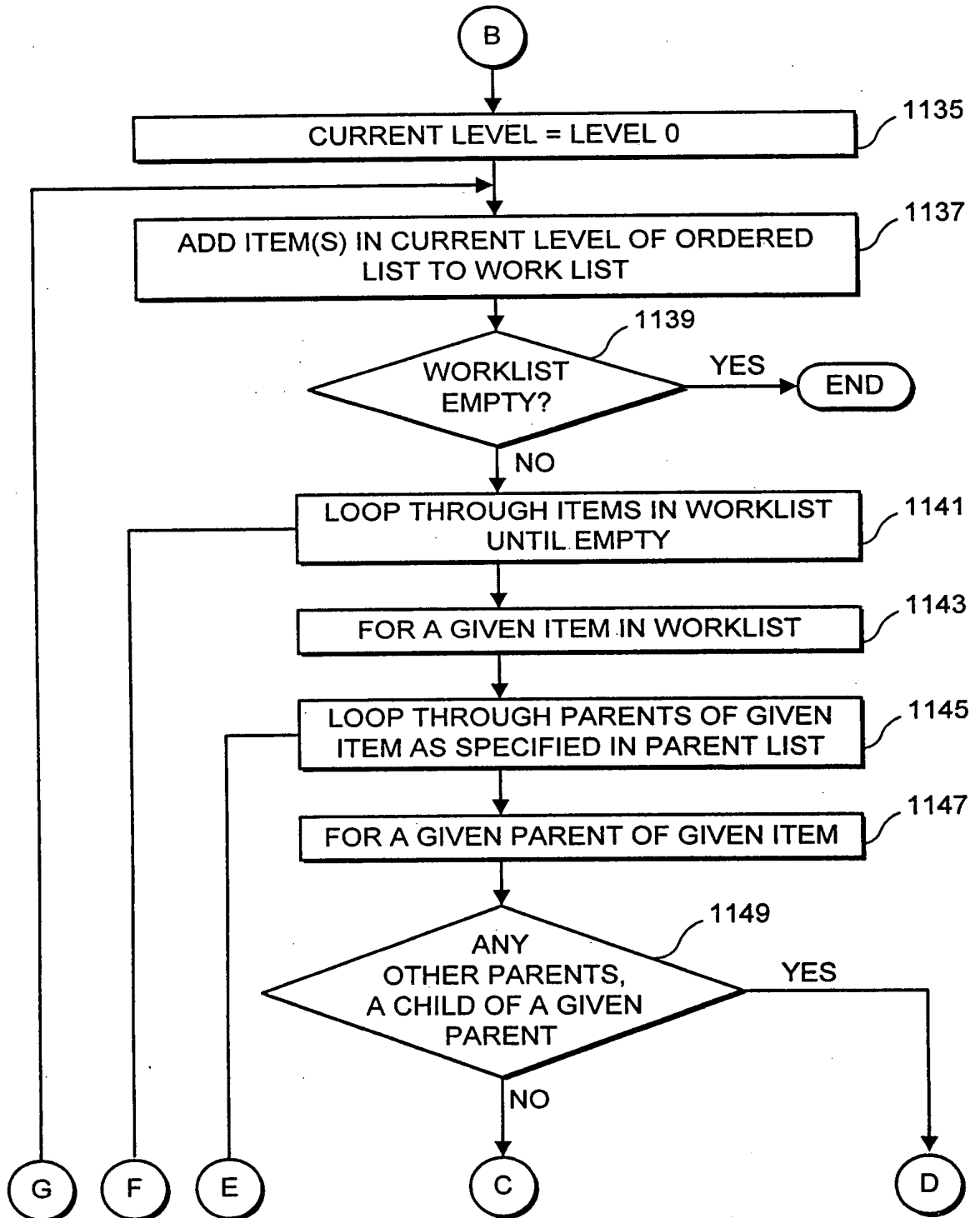


FIG. 11C(iii)

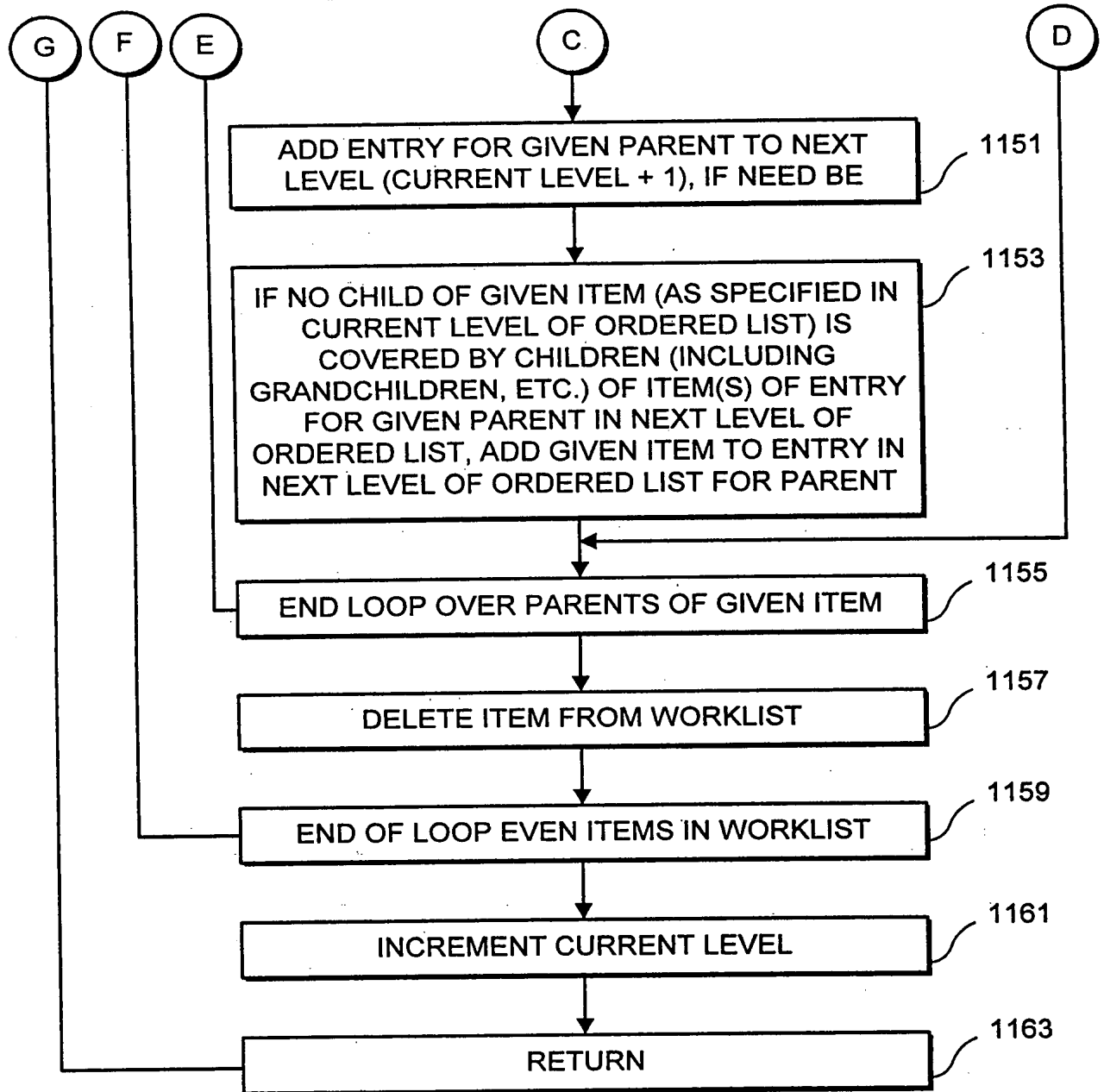


FIG. 11C(iv)

PARENT LIST

| ITEM | PARENT(S) |
|------|-----------|
| A | C, H, D |
| B | C, I, D |
| F | E, H, D |
| G | E, I, D |
| C | D |
| H | D |
| E | D |
| I | D |
| D | — |

FIG. 11C(v)

CHILD LIST

| ITEM | CHILD(REN) |
|------|------------------------------|
| A | — |
| B | — |
| F | — |
| G | — |
| C | <A, B> |
| H | <F, G> |
| E | <A, F> |
| I | <B, G> |
| D | <A, B, F, G>, <H, I>, <C, E> |

FIG. 11C(vi)

ORDERED LIST
LEVEL 0

| ITEM | CHILD(REN) |
|------|------------|
| A | — |
| B | — |
| F | — |
| G | — |

FIG. 11C(vii)

ORDERED LIST
LEVEL 1

| ITEM | CHILD(REN) |
|------|------------|
| C | A, B |
| H | A, F |
| I | B, G |
| E | F, G |

FIG. 11C(viii)

ORDERED LIST
LEVEL 2

| ITEM | CHILD(REN) |
|------|------------|
| D | C, E |

FIG. 11C(ix)

| |
|---------------------------------|
| AGGREGATION ENGINE |
| LOADING AND INDEXING MODULE |
| HIERARCHY TRANSFORMATION MODULE |

FIG. 12

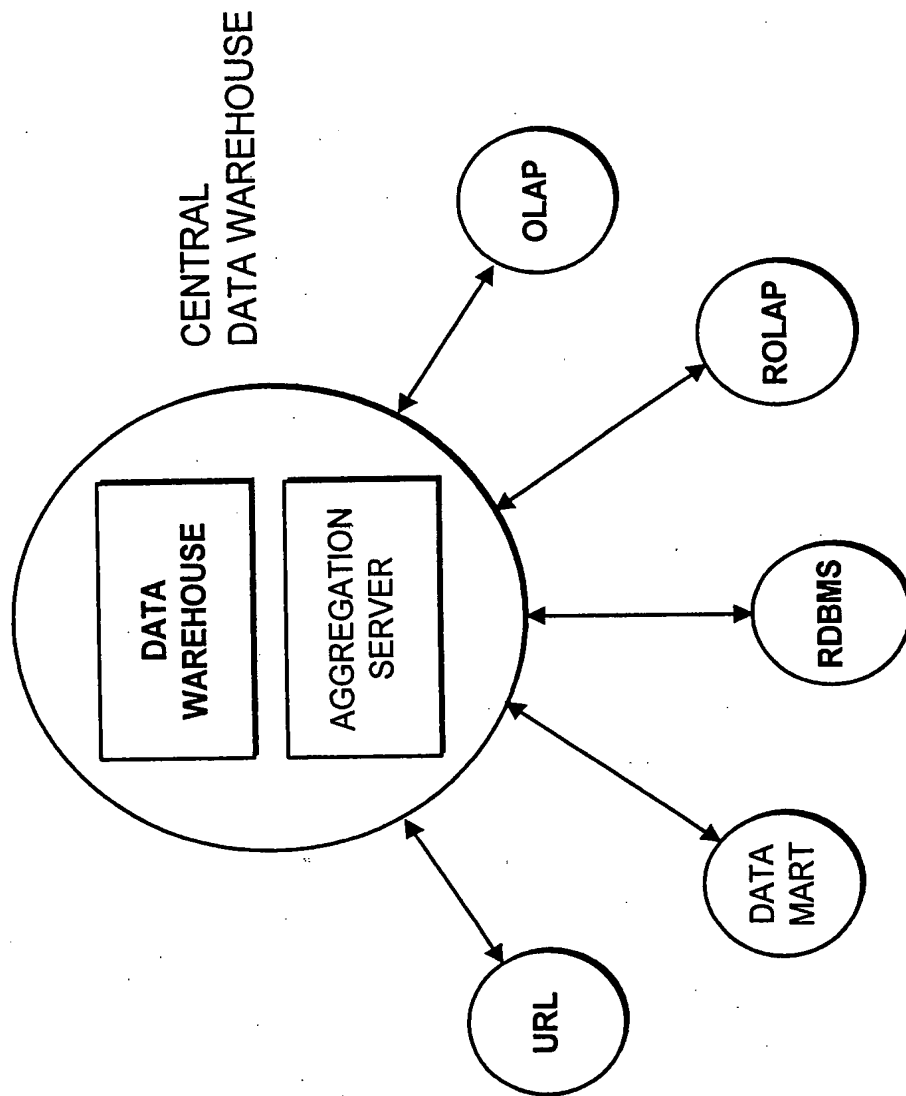


FIG. 13

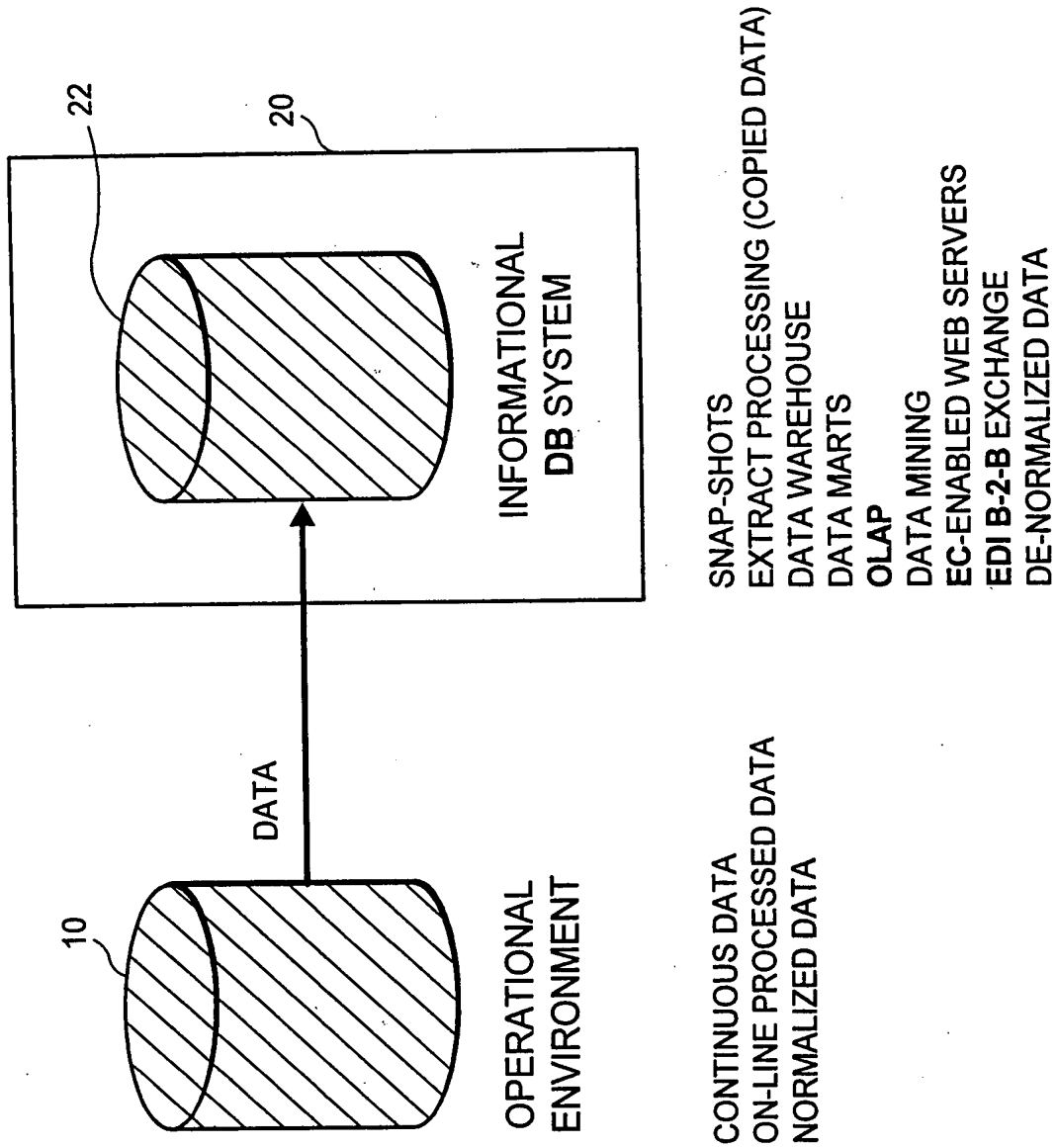


FIG. 14 (PRIOR ART)

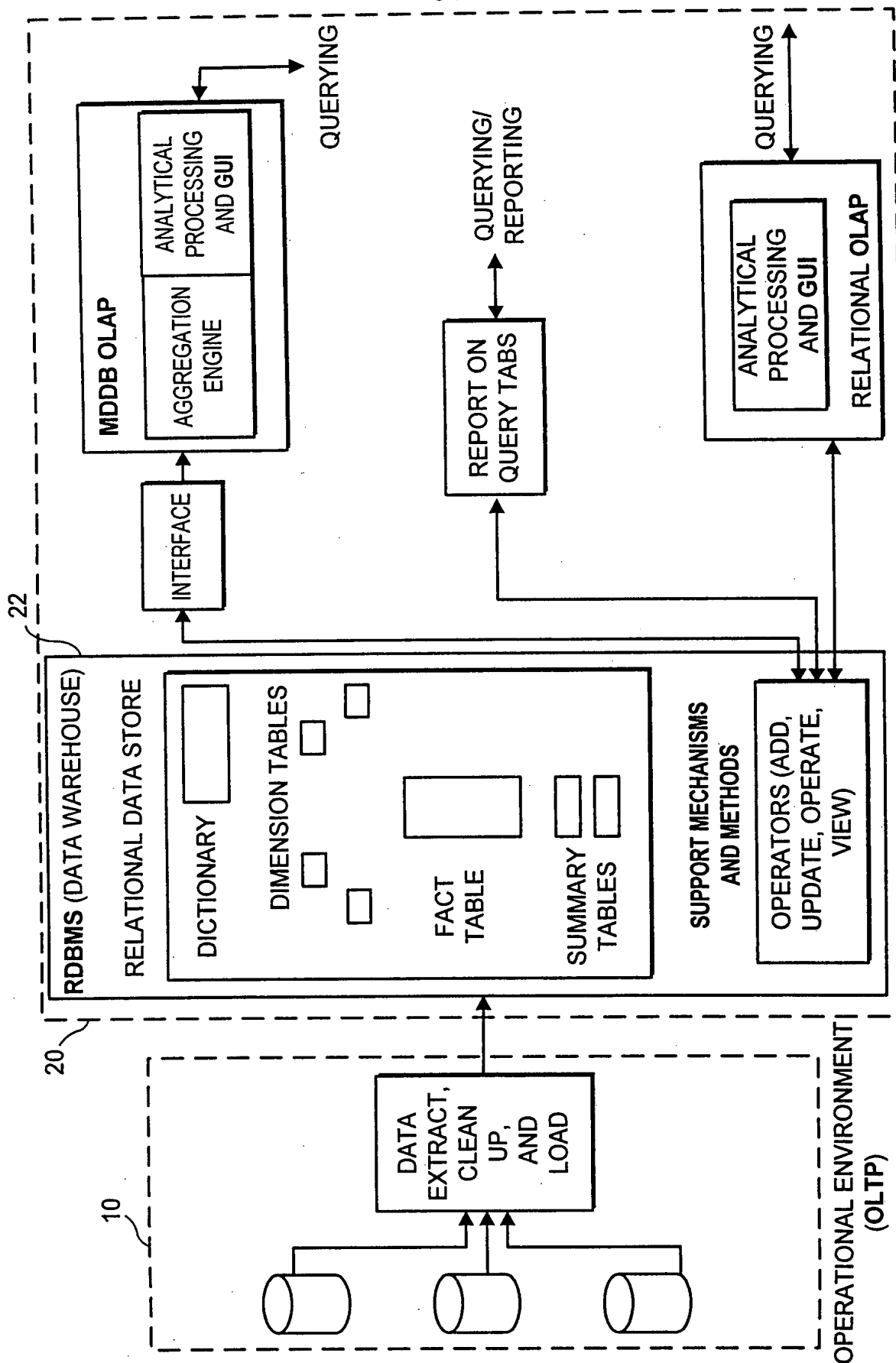


FIG. 15 (PRIOR ART)

CELLAR

| WINE | YEAR | BOTTLES |
|------------|------|---------|
| CHARDONNAY | 1996 | 4 |
| FUME BLANK | 1996 | 2 |
| PINOT NOIR | 1993 | 3 |
| ZINFANDEL | 1994 | 9 |

FIG. 16A

RESULT

RESTRICT: OPERATOR:
 SELECT WINE, YEAR,
 BOTTLES FROM CELLAR
 WHERE YEAR IS > 1995;

| WINE | YEAR | BOTTLES |
|------------|------|---------|
| CHARDONNAY | 1996 | 4 |
| FUME BLANK | 1996 | 2 |

FIG. 16B

RESULT

PROJECT: OPERATOR:
 SELECT WINE, BOTTLES
 FROM CELLAR;

| WINE | BOTTLES |
|------------|---------|
| CHARDONNAY | 4 |
| FUME BLANK | 2 |
| PINOT NOIR | 3 |
| ZINFANDEL | 9 |

FIG. 16C

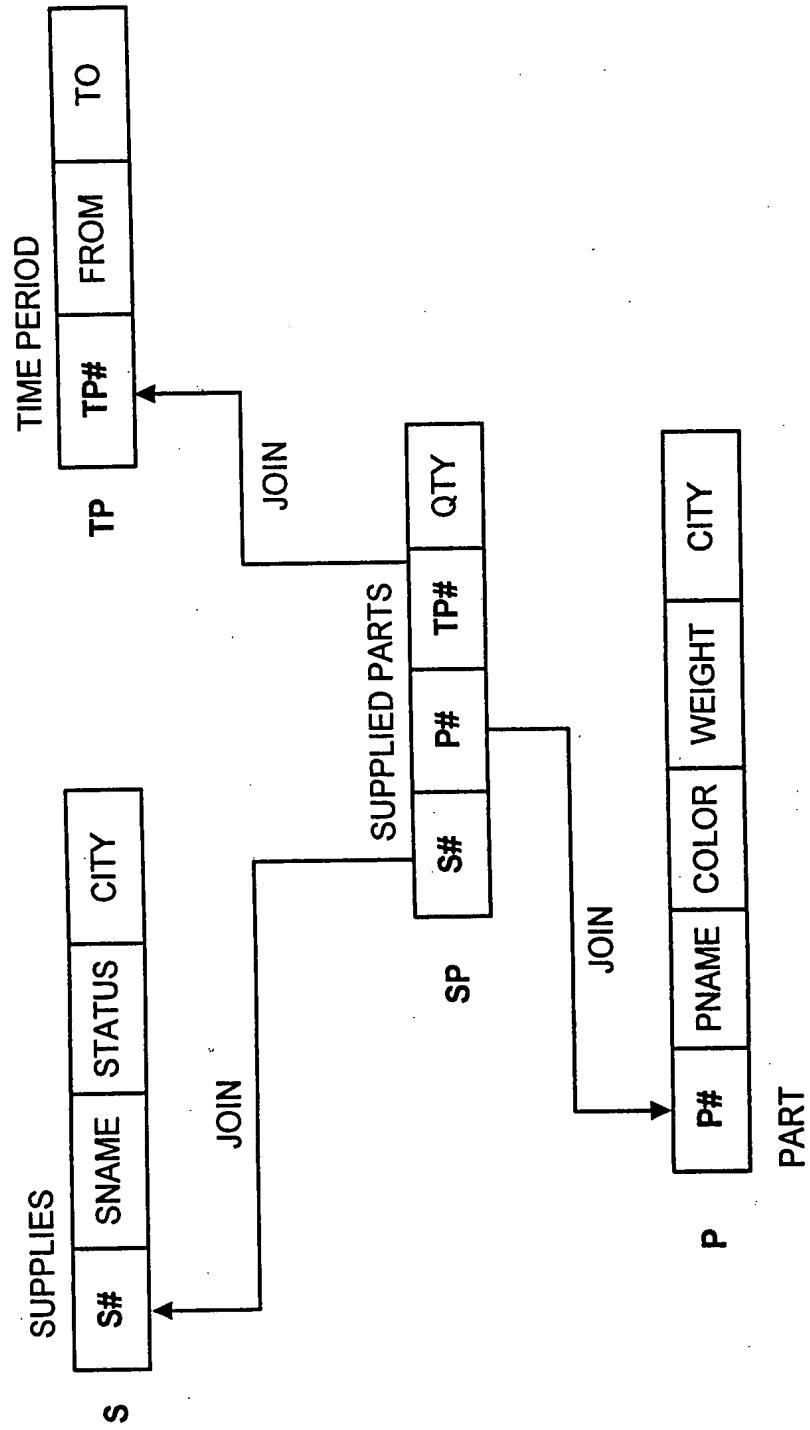


FIG. 17A

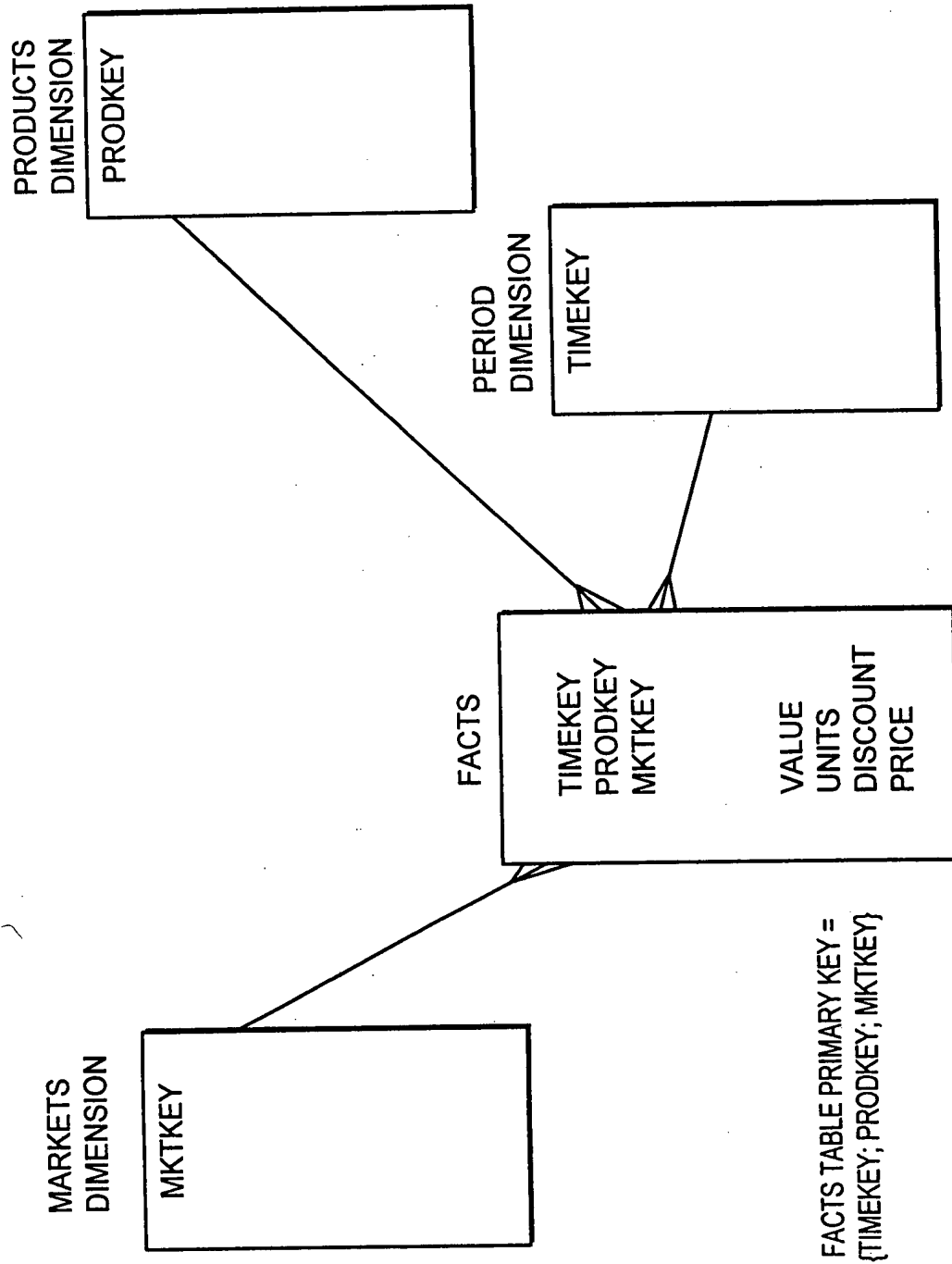


FIG. 18A

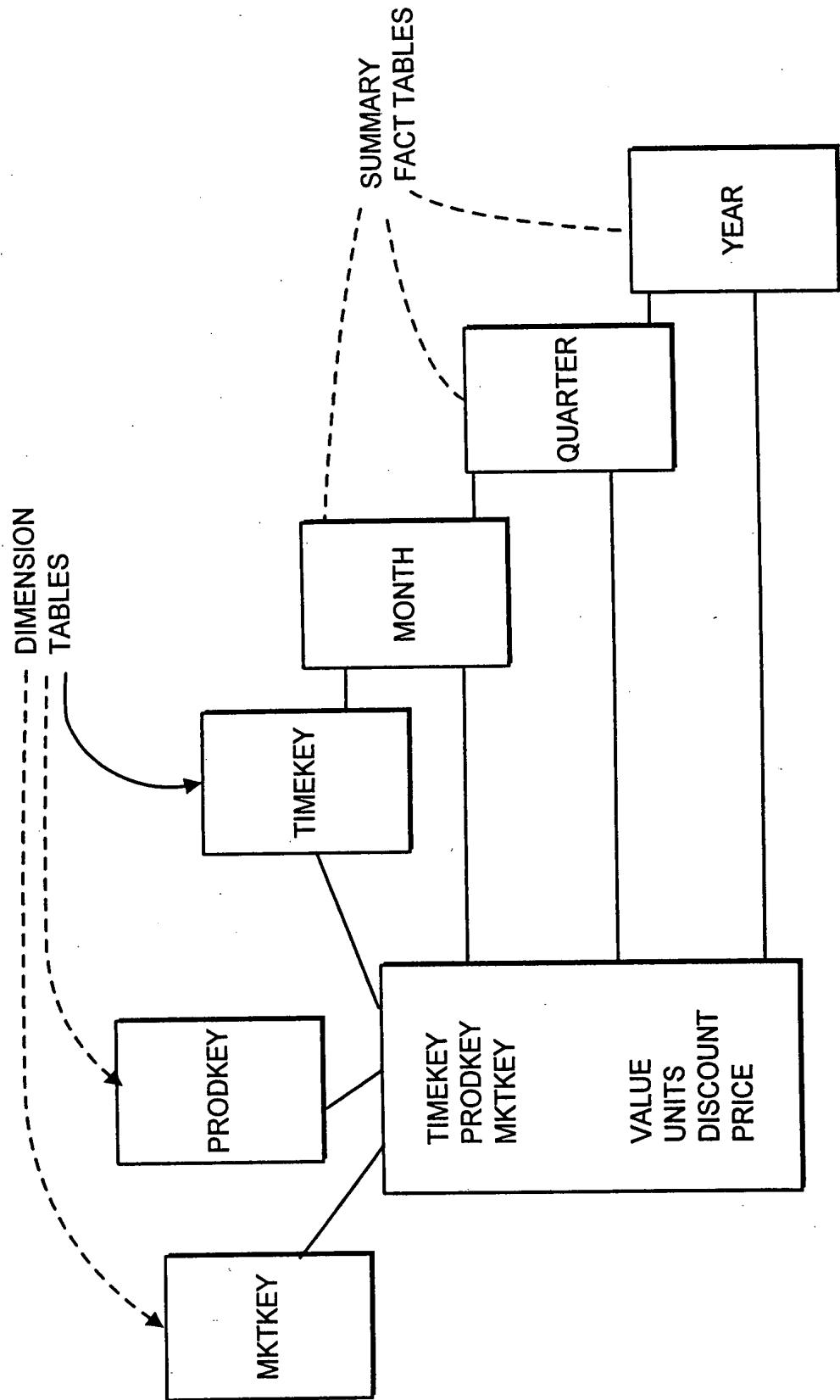


FIG. 18B

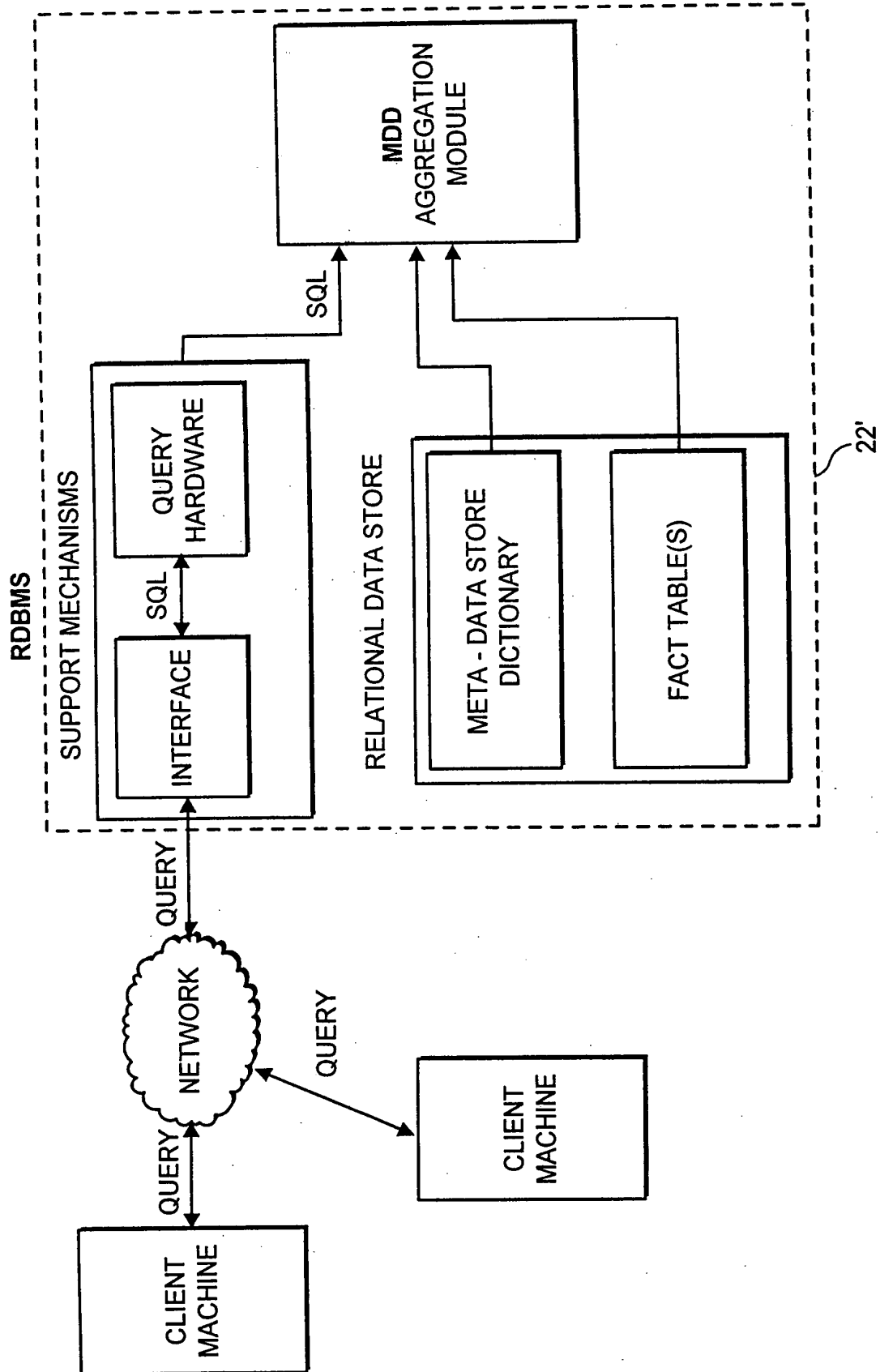


FIG. 19A

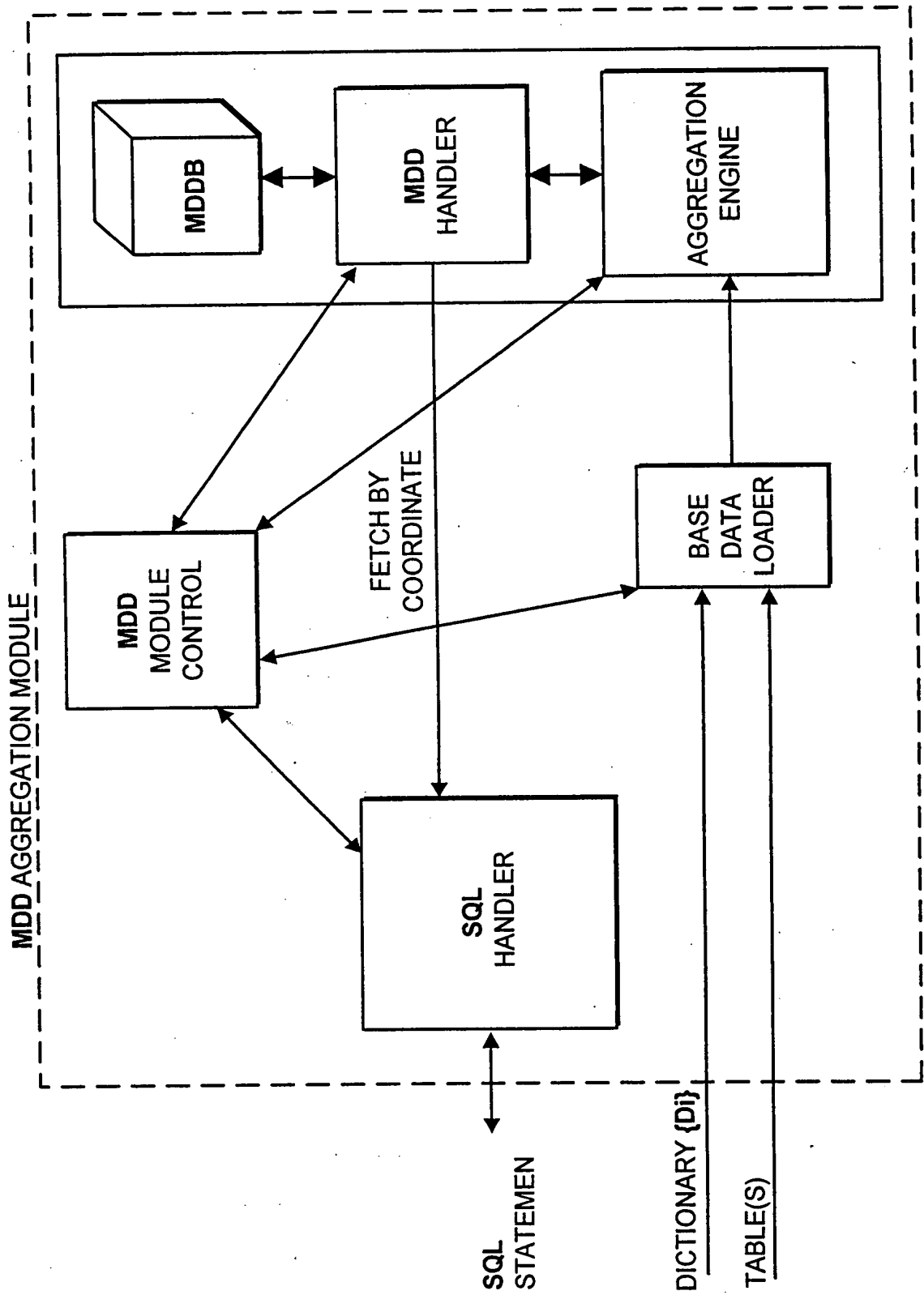


FIG. 19B

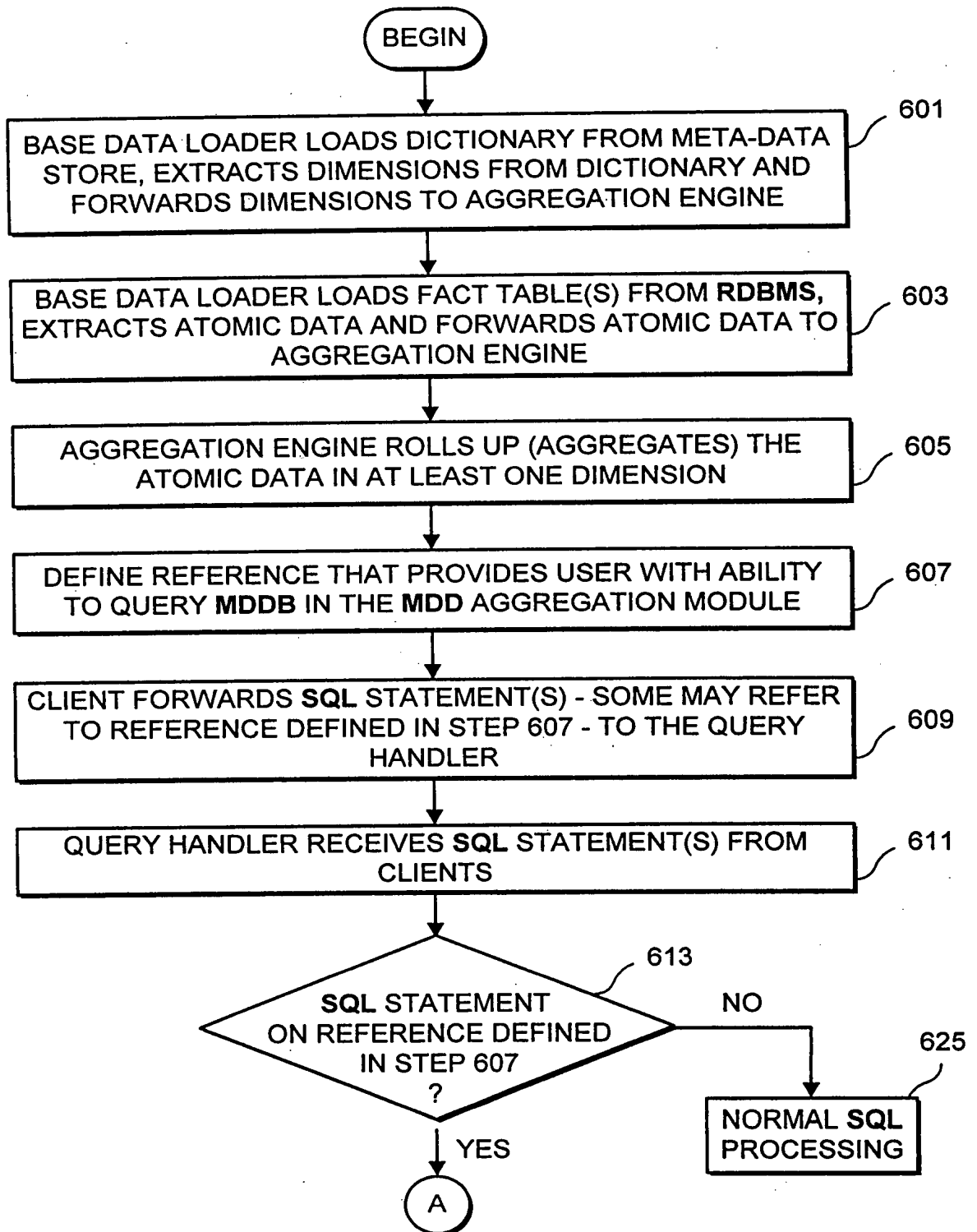


FIG. 19C(i)

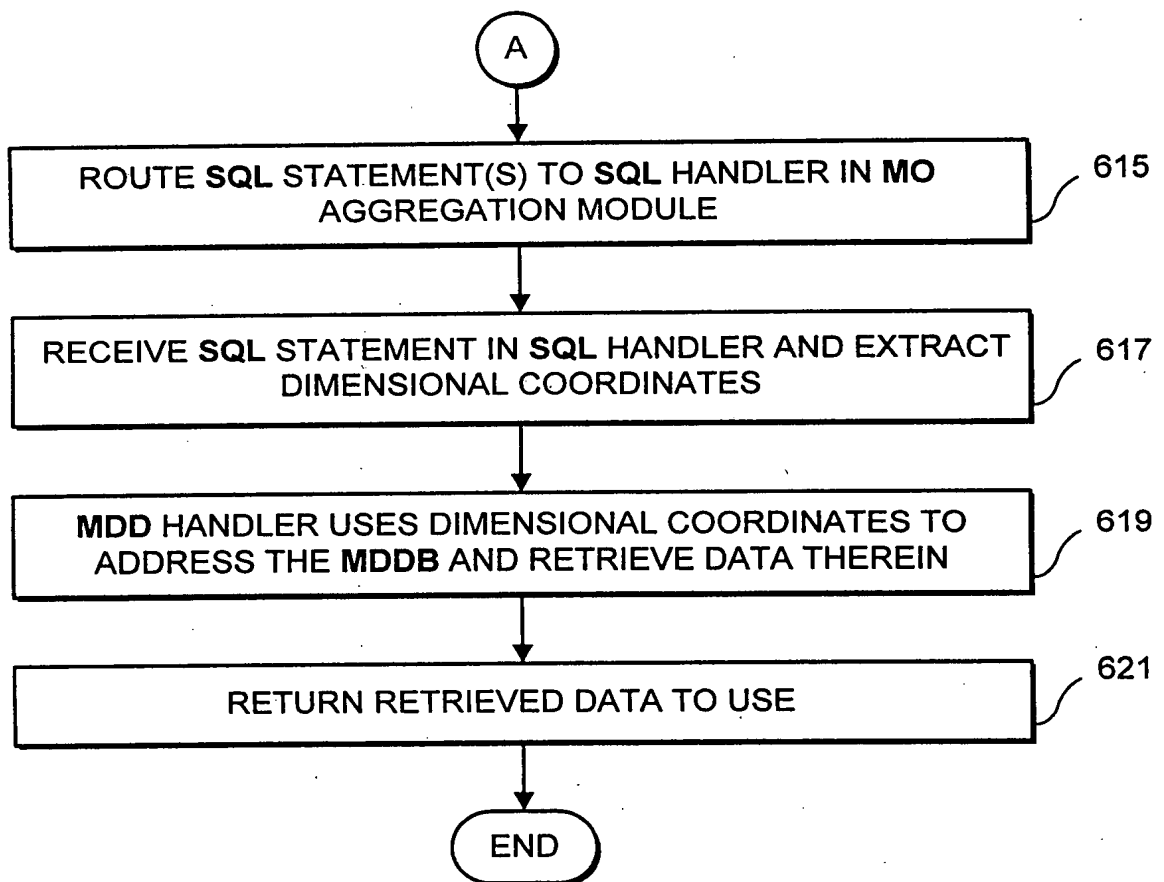


FIG. 19C(ii)

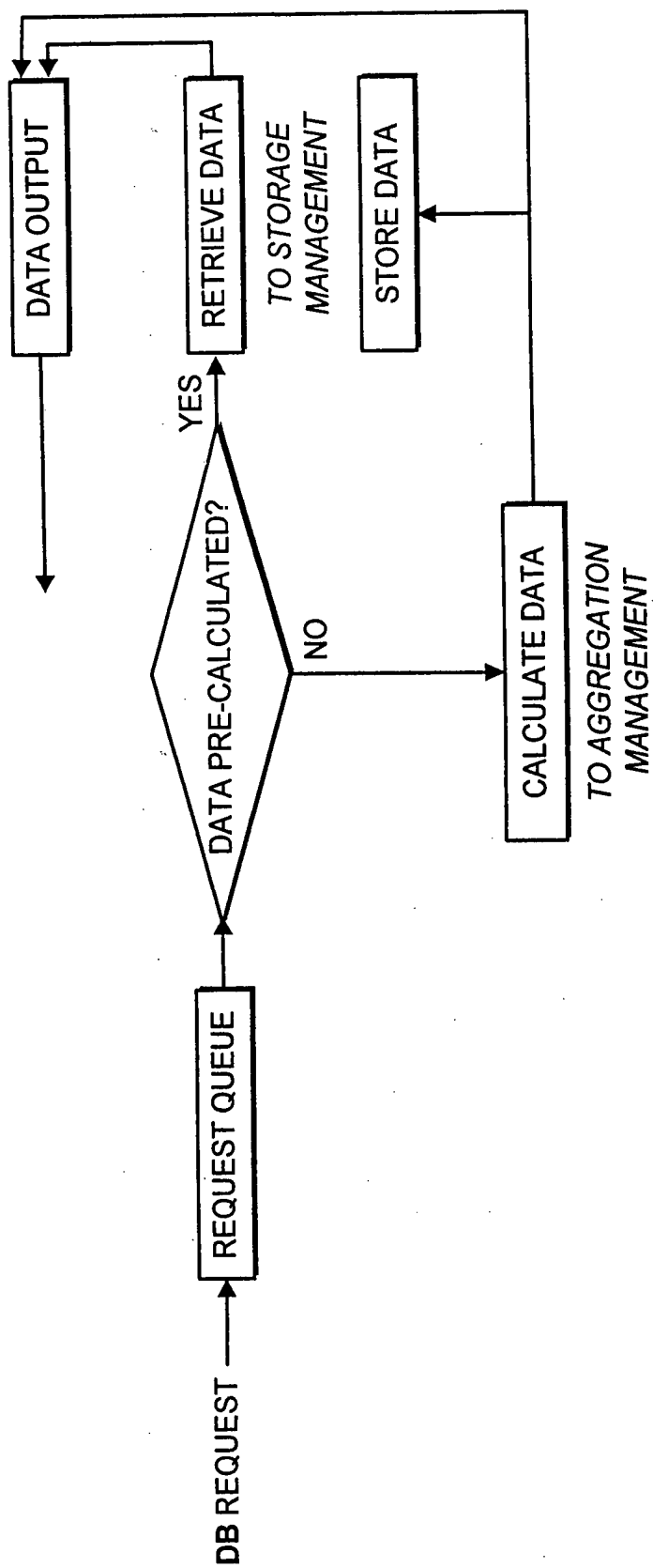


FIG. 19D

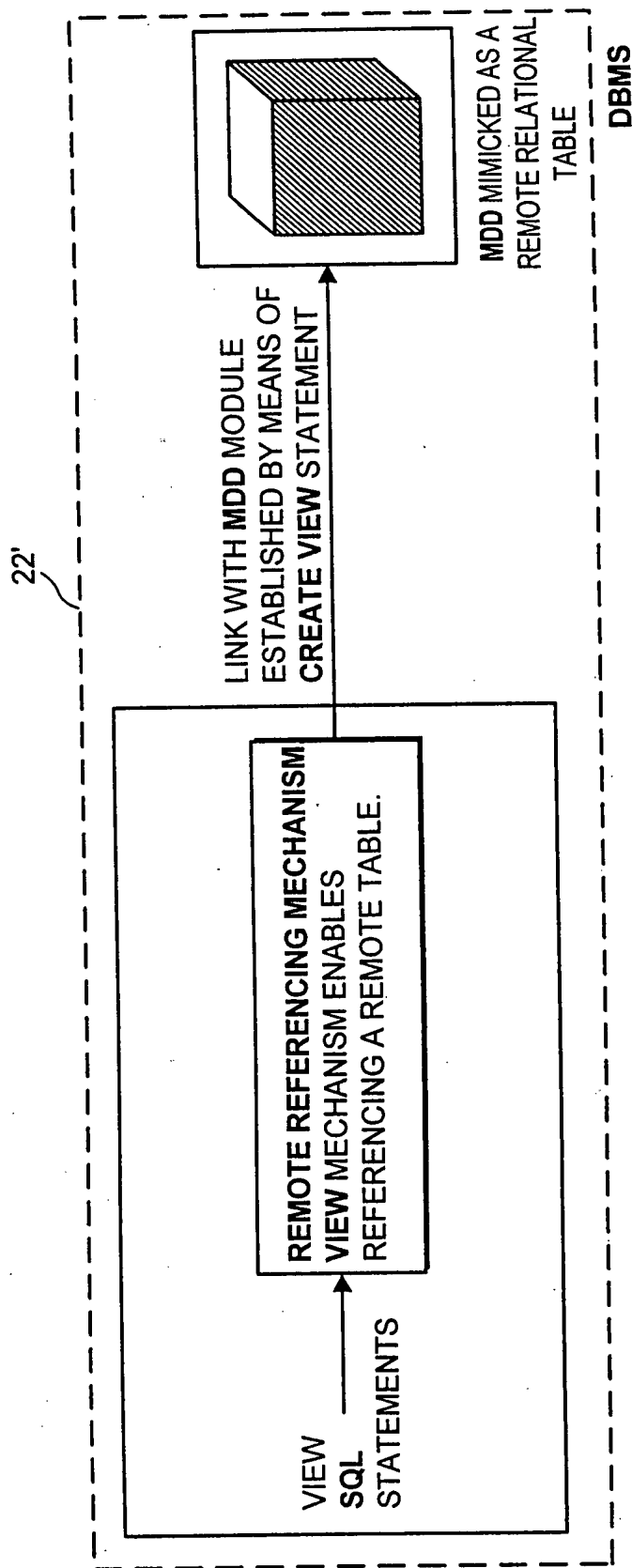


FIG. 19E

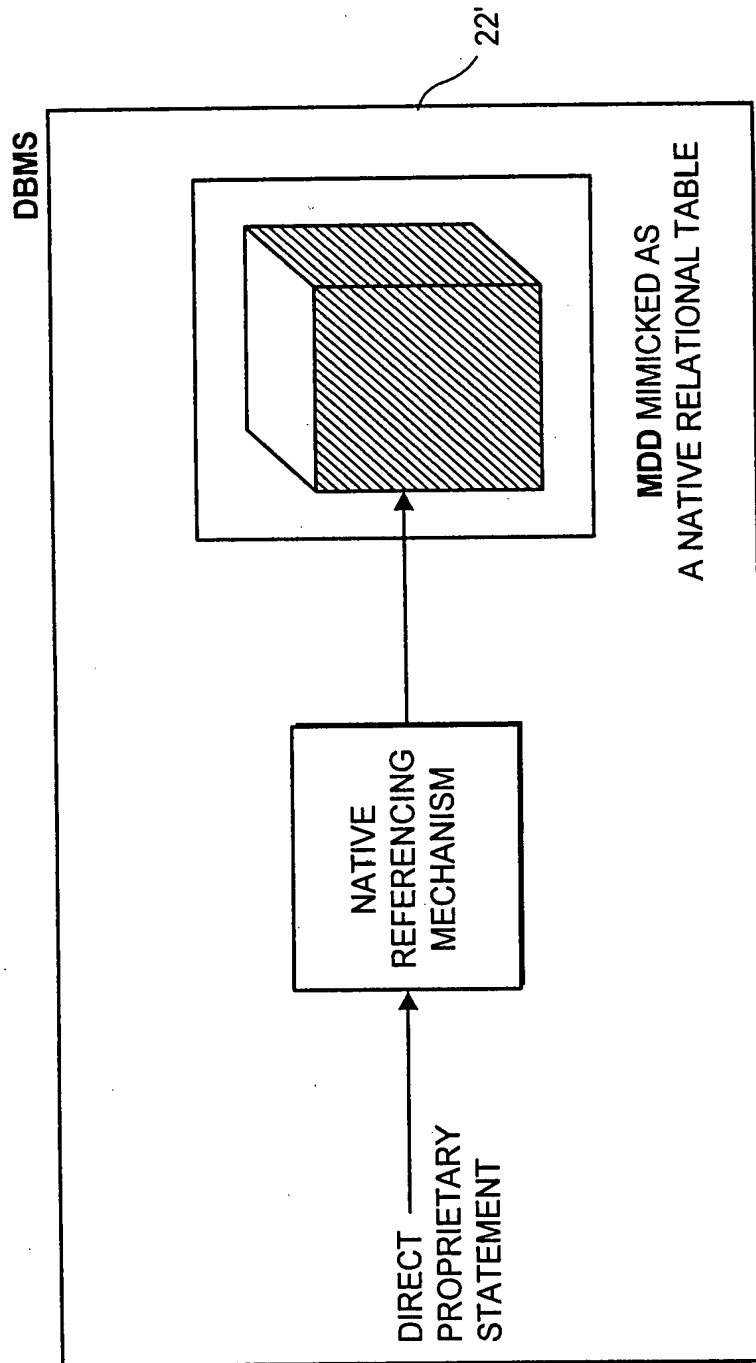


FIG. 19F

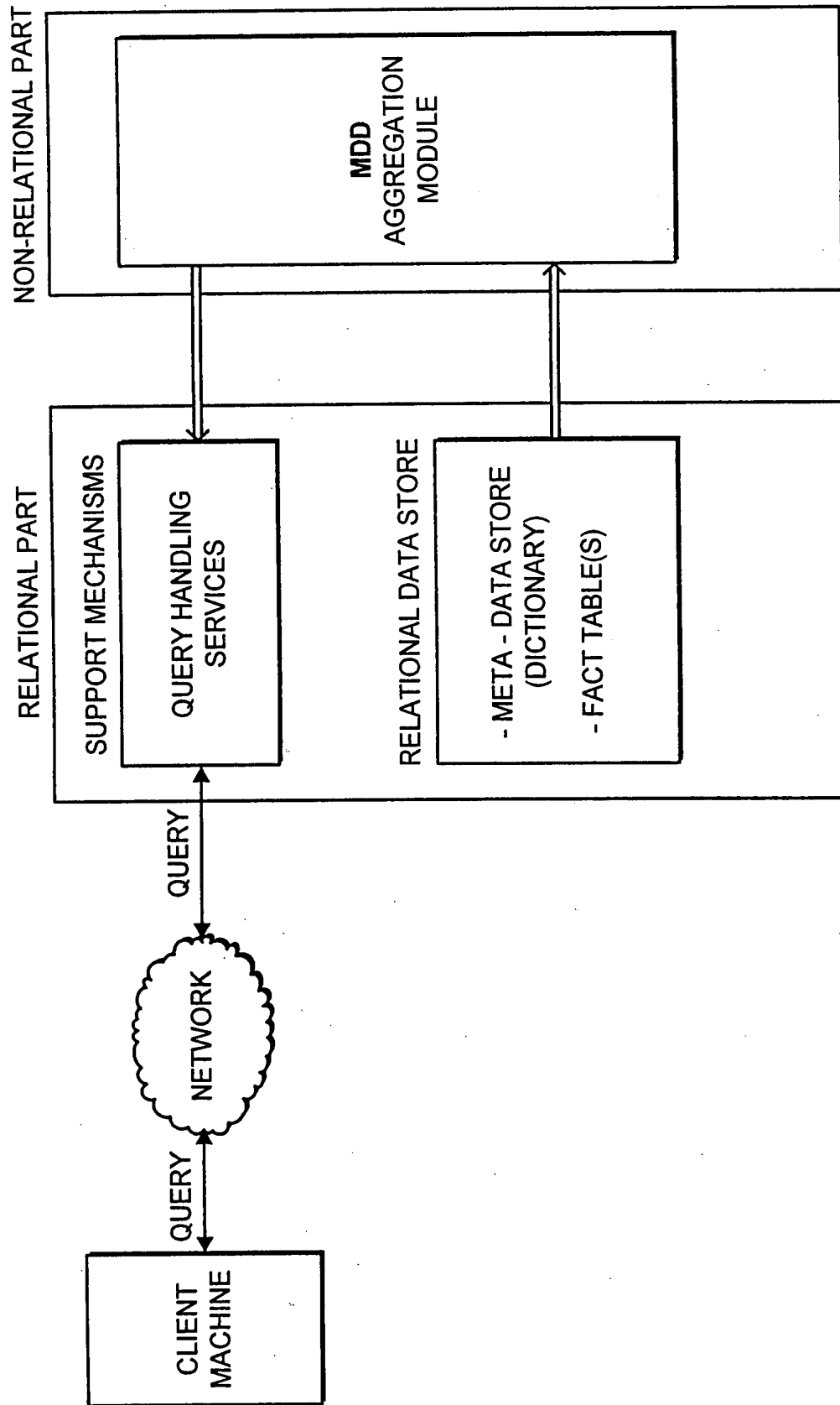


FIG. 19G

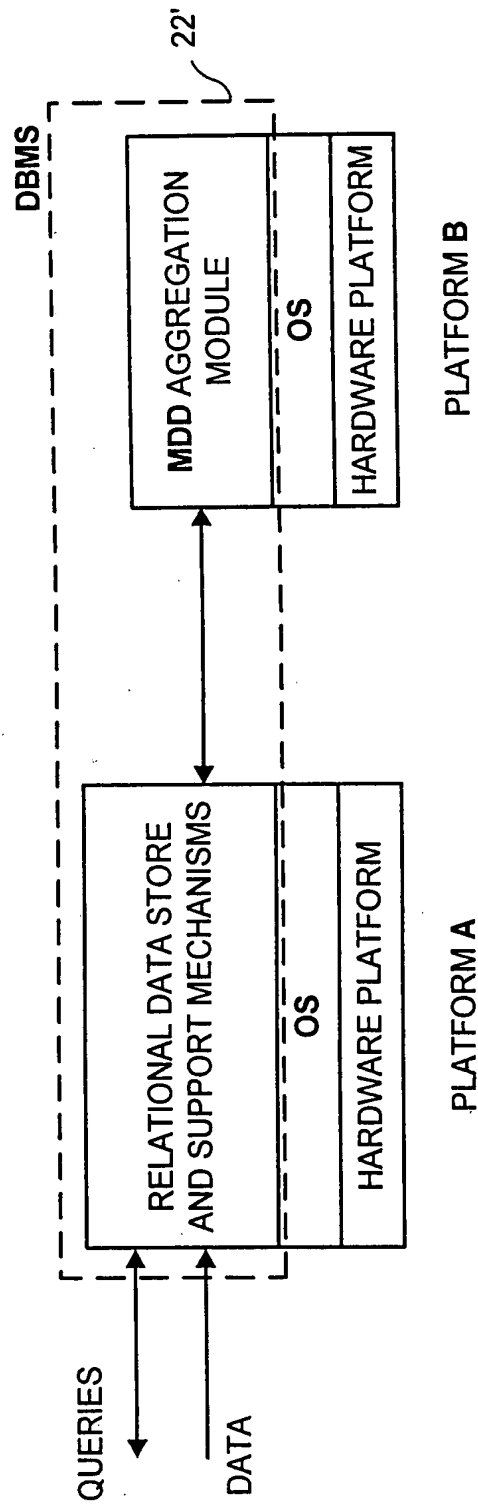


FIG. 20A

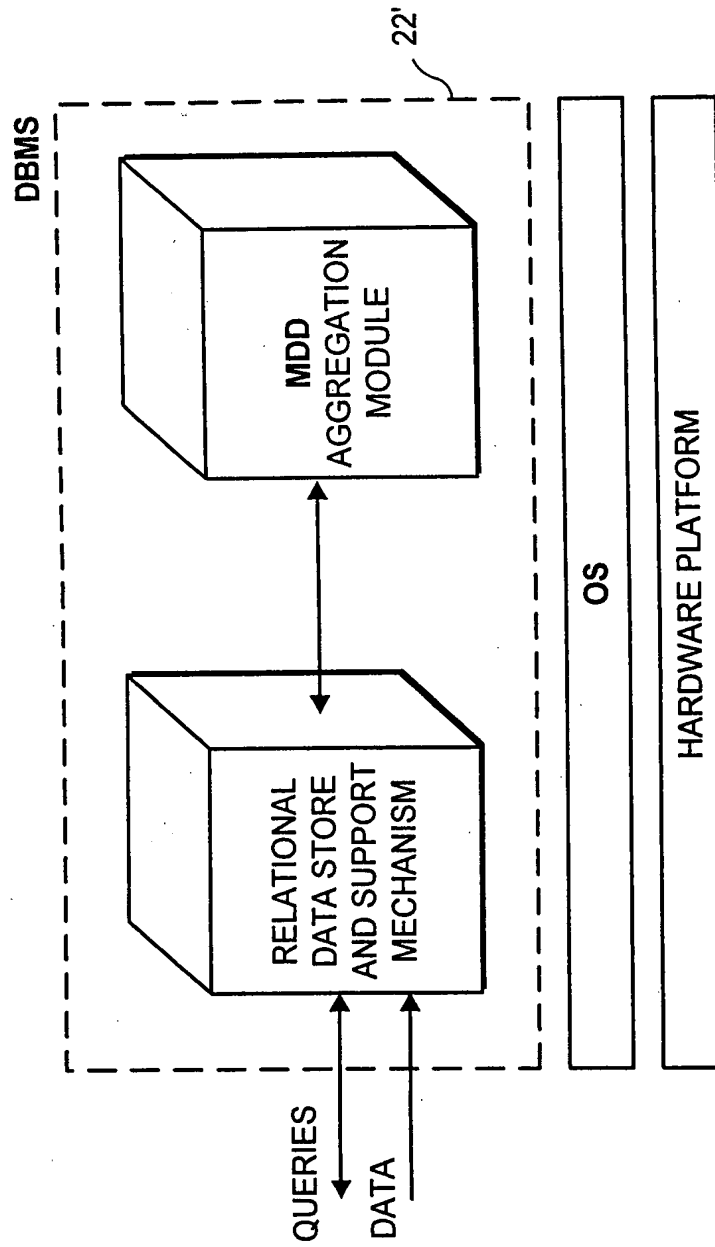


FIG. 20B

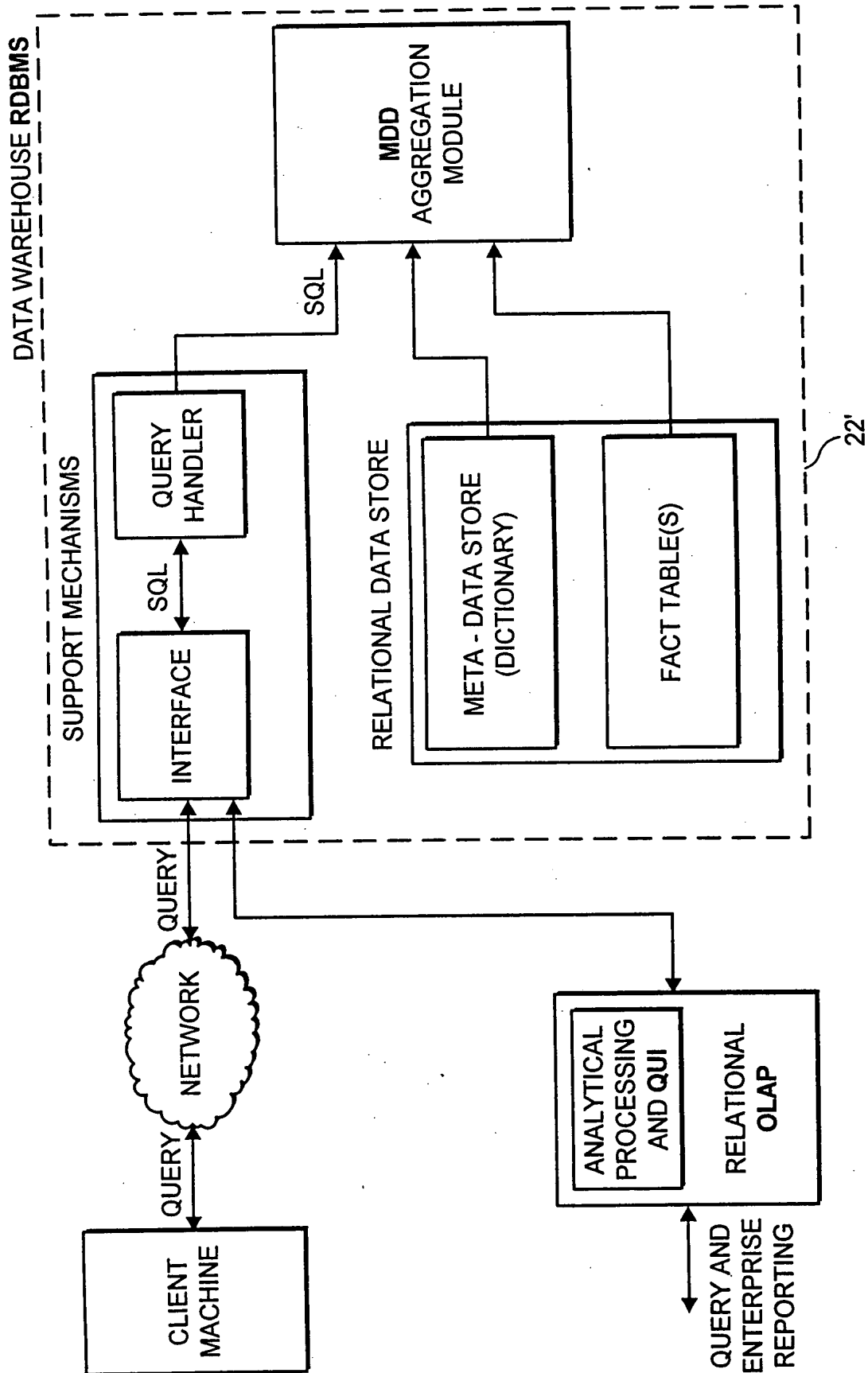


FIG. 21

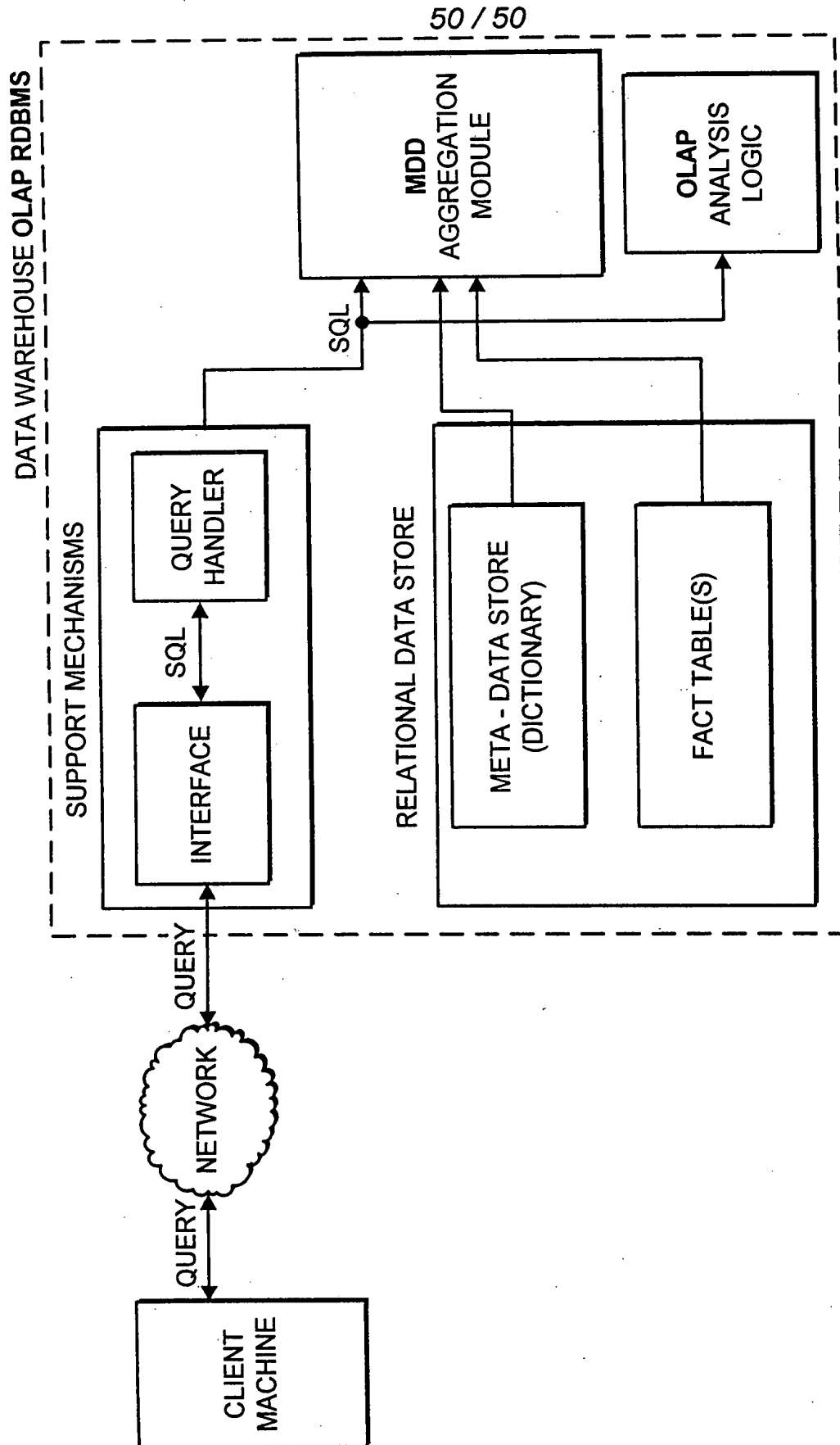


FIG. 22